THE
BRITISH JOURNAL OF SURGERY

VOL. XXVI APRIL, 1939 No. 104

TUBERCULOSIS OF THE SPLEEN WITH TUBERCULOUS SUBPHRENIC ABSCESS

BY W. G. GILL
RESIDENT SURGICAL OFFICER AND SURGICAL REGISTRAR, GUY'S HOSPITAL
AND W. N. MANN
MEDICAL REGISTRAR, GUY'S HOSPITAL

TUBERCULOSIS of the spleen in which enlargement of that organ is a prominent feature of the disease, and which is unassociated with generalized miliary dissemination, is rare. About a hundred cases occurring in man are described in the literature, and in addition, a similar clinical picture occurring in apes is described. The particular interest of the case which is studied here is that the condition was complicated by a subphrenic abscess which was the result of breaking-down of the caseating spleen, and the occurrence of a possibly tuberculous cutaneous eruption before the splenic disease was manifest.

The term " primary tuberculosis of the spleen " is employed in describing the condition with which we are concerned. By this term we imply a condition in which enlargement of the spleen is the presenting and outstanding clinical finding. The term is a bad one, because the word " primary " is not intended to suggest that the spleen is the first organ in the body to be attacked by the tubercle bacillus when the organism gains entry. In fact, in these cases it is usual to find described obvious involvement either of the mesenteric or of the tracheobronchial lymph-glands, which indicates the portal of infection. Winternitz (1912) summarized 51 cases of this condition, and remarks that other tuberculous lesions are practically always present, particularly in the lymph-glands. The mesenteric nodes are those chiefly affected. In his series, the disease was limited to the spleen and liver in only 3 cases, and to the spleen in only 1 case. He found that the disease was most common in the third and fourth decades, and that most patients showed clinical enlargement of the spleen, or complained of pain in the region of that organ. Other symptoms described include lassitude, loss of weight, and anæmia. Polycythæmia has been observed. The pain may be related to meals or to respiration, or it may be of a persistent character.

Shands (1933) described 3 further cases, and states that since the publication of the paper by Winternitz, only twenty or thirty cases have been described. One of Shands' cases showed involvement of the spleen alone—it contained five calcareous nodules " as large as marbles " ; another case was associated with abscess formation in the omentum. Besides our own case, this is the only reference in the literature

that we have been able to find in which tuberculosis of the spleen was complicated by an associated abscess. Shands remarks that there is no characteristic symptomatology by which the disease may be distinguished clinically from other forms of splenomegaly.

This type of nodular tuberculosis of the spleen, associated often with tuberculosis of the liver of a similar but usually less advanced type and with caseation of either the mesenteric or of the tracheobronchial lymph-glands, is not uncommon in apes. References will be found in the papers of Lindemann (1921), Scott (1930), and Finkeldey (1931). The earliest descriptions of the simian form are quoted by Kalbfleisch and Nohlen (1929) from a paper by Lebert published in 1874. Lebert analysed the incidence of the disease in various organs in 38 cases of tuberculosis in apes. He found that lesions occurred in both the liver and the spleen in two-thirds of the cases, while tuberculosis of the lungs was present in only a quarter. Renal lesions were about as common as those in the lungs. The bronchial lymph-nodes showed tuberculous lesions in 30 per cent, the incidence being slightly higher than that in the mesenteric nodes, where it was 25 per cent of the cases. This analysis suggests that intestinal and pulmonary sites of primary inoculation are about equally frequent. Nieberle (1932) states that " intestinal " and " pulmonary " tuberculous infection occur in apes with much the same frequency, and that in those cases where both the liver and the spleen are involved, the intestine is usually the route of infection.

The frequent involvement of the spleen in patients showing ' miliary ' or ' nodular ' tuberculosis affecting one or more organs in the body is remarkable. Cyman (1930) suggests that this is due to an elective affinity of the bacillus for the spleen; Scott (1930) that it is possibly associated with the meeting in the spleen of the blood-stream with the lymphatic circulation. Whatever be the explanation, several authors (Flandrin, 1931, and Cyman), make the comment that the lesions in the spleen are usually older than those in the liver, and, when renal infection is present as well, than those in the kidneys.

If the infection is carried from the lymphatic system into the blood-stream via the ' splenic filter ', then it will not be remarkable if the splenic lesion is older than those which may occur in other viscera, and which represent the final hæmatogenous spread as the ultimate result of breakdown of a primary lymphatic focus either in the mesenteric or the tracheobronchial lymph-glands. Nor will it be remarkable that splenic lesions should be common in miliary tuberculosis. Further, the curious fact that the spleen may occasionally be affected without other visceral tuberculosis, might be explained. The infection resulting from a small dosage of an organism of low virulence might well be localized in the spleen.

Apart from tuberculosis of the liver in association with tuberculosis of the spleen, several authors describe coincident hepatic cirrhosis. Flandrin reports a case in which tuberculosis of the spleen together with cirrhosis of the liver was associated with perforation of the stomach from a vascular thrombosis. A minute caseating area was also present in the left kidney. Cain (1932) reports a case of a splenic tumour, weighing 1950 g., which showed caseous areas and which was associated with cirrhosis of the liver, the liver also containing small tubercles from which tubercle bacilli were recovered. The case had been compared clinically with Banti's syndrome.

CASE REPORT

We shall now describe a case of " primary " tuberculosis of the spleen, including a report on the post-mortem bacteriological investigations by Dr. E. Sayle.

HISTORY.—The patient, a male aged 27 years, with no relevant family or personal history, in April, 1937, after an attack of "influenza", developed erythematous lesions on the points of the elbows and on the ankles, which became bullous and later pustular. They healed quite quickly, forming rather exuberant granulations, but the lesion on the left shin became more active and spread. This had a purplish œdematous edge, and a firmly adherent slough, which on removal revealed bright red granulation tissue (*Fig.* 452). Cultures, both superficial and deep, gave growth of moderate-sized diphtheroids, with mild polar staining. Otherwise the only organisms grown were staphylococci and a few saprophytic organisms. The ulcer was thought to be due to the organisms recovered, and the original bullous lesions may have been a toxic erythema multiforme secondary to the attack of influenza. Some observers consider tuberculosis as one of the causes of erythema multiforme. Thus Ramel (1930) reported successful tuberculinization of guinea-pigs with blood from patients with erythema exudativum multiforme. It is therefore possible that in the case described here, the skin lesions were tuberculous in origin.*

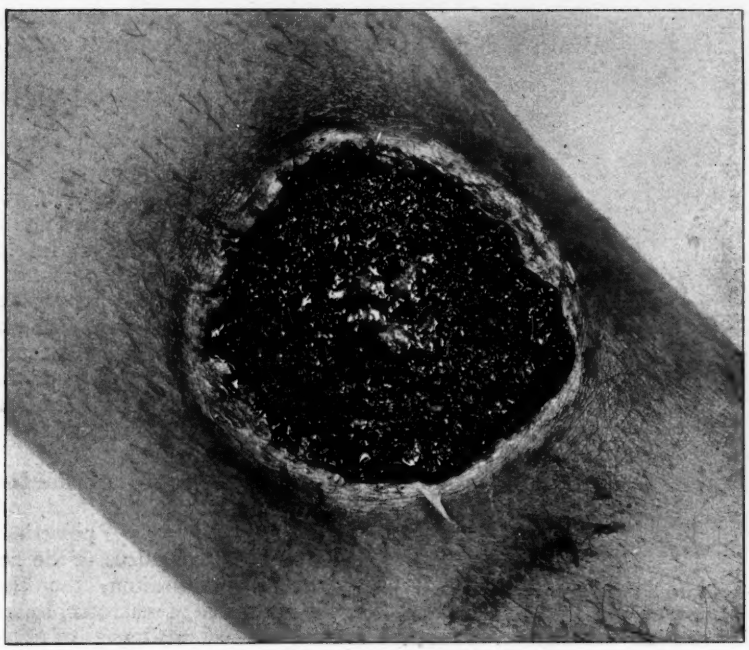


FIG. 452.—Cutaneous lesion on left shin. (*Reproduced by kind permission of the Royal Society of Medicine.*)

For the next few months the patient ran a continuous pyrexia, occasionally rising as high as 103·8° F., while his pulse-rate was in the neighbourhood of 130 beats per minute. The ulcers healed, but the patient's general condition deteriorated, though no new signs or symptoms made their appearance. Occasionally mild polymorphonuclear leucocytosis was observed, and on one occasion a positive blood-culture of *Staph. aureus* was found. Although blood-culture was many times repeated, no further positive finding was made.

In August, 1937, his hæmoglobin was 50 per cent and his sedimentation rate was 49 mm. in the first hour.

In September he complained of pain in the lower part of the left side of his chest, in the left subcostal region, and at the tip of the shoulder. Rapid deterioration in his general condition ensued, and a diagnosis of subphrenic abscess was made.

* The patient was shown at the Royal Society of Medicine by Dr. L. Forman (1937), to whom we are indebted for these notes.

When seen on October 10, 1937, he looked very pale and ill. His temperature was 103·8° F. and his pulse-rate 140 beats per minute. There was œdema of the chest wall on the left side from the sixth rib downwards. The apex beat was in the fourth space in the nipple line. Percussion revealed stony dullness from the fifth rib down into the abdomen, while there was intercostal and subcostal tenderness. There was no evidence of a pleural effusion. The diagnosis of subphrenic abscess was confirmed by radiography, which showed the presence of an opacity under the left side of the diaphragm (*Fig.* 453). No gas was seen, and there was no radiological abnormality of the lungs. In view of the absence of any obvious pre-existing abdominal disease, the abscess was considered to be pyæmic in origin.

AT OPERATION (W. G. G.).—Under gas and oxygen anæsthesia following evipan induction, the subphrenic space was needled through the ninth space in the posterior axillary line. Odourless, creamy pus was found, and part of the ninth rib resected. The pleural space was not obliterated and the pleura could not be stripped upwards. The space was accordingly obliterated by sutures and the diaphragm incised. About a pint of pus was evacuated. On exploration of the cavity with a finger it was noticed that the normal position of the spleen was occupied by a necrotic mass. A suppurating splenic infarct was diagnosed. Cultures of the pus proved sterile.

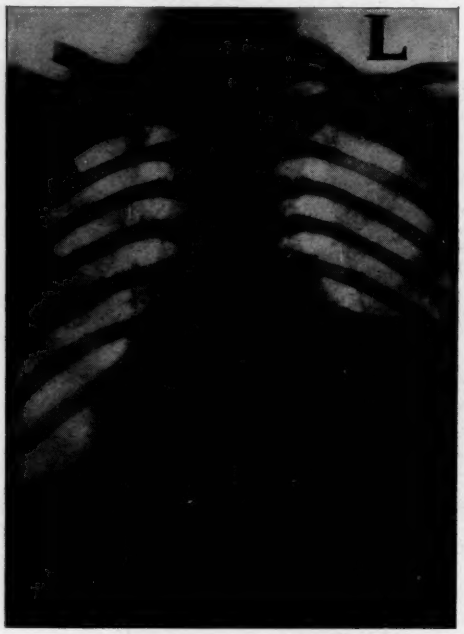


FIG. 453.—Radiograph showing left subphrenic opacity.

The abscess drained well, but the condition of the patient did not improve. Re-exploration was carried out on November 2, 1937, but the patient continued to go downhill, and after developing signs of pulmonary infection he died on November 23, 1937.

AT AUTOPSY.—The autopsy was carried out on the day following death. The cadaver was somewhat wasted and there was a surgical wound over the posterolateral aspect of the ninth rib on the left side where resection had been performed. No other abnormalities were to be seen on external examination.

The *pericardial sac* contained about twice the normal amount of clear fluid, and except for a small ecchymosis on the posterior part of the auriculo-ventricular sulcus of the heart beneath the visceral pericardium, the cardiovascular system was devoid of macroscopical abnormality, although microscopical examination of the myocardium showed small areas of necrosis accompanied by a polymorphonuclear and macrophage reaction.

The *larynx* was injected and contained mucopus. The large and small *bronchi* contained purulent material. Both *lungs* were covered by a fairly recent pleural exudate so that the pleural cavities were obliterated. There was no free fluid. At the left base the exudate was so thick that it had effectively prevented the spread of infradiaphragmatic suppuration into the lung on that side, although at one point the diaphragm had completely sloughed away. Both lungs were deeply congested and showed suppurative bronchitis, most marked in the lower parts. There were no abscesses, emboli, or thromboses in the lungs. The tracheobronchial glands were soft, but did not show any caseation. No old tuberculous scarring of the lungs was seen.

The alimentary system was devoid of any abnormality. The tonsils were healthy, and the peritoneum, other than that part in direct relationship with the spleen, showed no morbid process. There was no enlargement of the mesenteric lymph-glands other than those in relation to the hilum of the spleen (*vide infra*).

The *liver* was a little enlarged, deeply congested, and showed some fatty change Throughout the liver there were discrete yellow areas varying in size from one-tenth of an inch to an inch in diameter (*Fig.* 454). They were well demarcated from the surrounding tissues.

and pale chrome yellow in colour; some projected from the surface. On section, the largest of them showed a honey-combed appearance not unlike that associated with actinomycosis of the liver, but they were of brighter colour. A good deal of fibrous tissue was present in these nodules, the interstices being filled with sulphur-coloured pus. There was practically no surrounding hyperæmia. The capsule of the liver was adherent towards the left to the capsule of the spleen. There was no thrombosis of the portal vein. Histological examination of the liver showed that these yellow areas were composed of areas of necrosis, with endothelioid cells in the centre and lymphocytes and polymorphonuclear cells at the periphery.

FIG. 454.—Section of the liver. (× ⅔.)

There were only very few giant cells present, but the histology was very suggestive of tuberculosis.

The *biliary apparatus* and the *pancreas*, except that this latter organ was adherent by its tail to the spleen, were devoid of abnormality.

The *spleen* weighed 672 g. and was altogether remarkable. It was enlarged to a diameter of five inches and was spherical in shape. The upper pole was adherent to the diaphragm and, where this was deficient, to the pleura. On section, practically no splenic tissue could be seen except for small isolated pieces towards the lower pole. The greater part of the organ was occupied by a honeycombed yellow mass (*Fig.* 455). The walls of the 'honeycomb' were of fibrous tissue, and, exactly as in the liver, the interstices were filled with thick yellow pus. The condition differed from that in the liver only in its extent and in that the whole organ was occupied by a single abscess. The upper pole of the organ had completely sloughed away and communicated with the subphrenic space, which was shut off from the peritoneal cavity by adhesions and was filled with necrotic bloody material. There was no direct communication between the spleen and the caseous areas of the liver. The splenic vessels in the immediate neighbourhood were thrombosed, and the lymph-glands in the immediate area of the hilum were enlarged, white, and rather soft, but did not show caseation.

Microscopical examination of the spleen showed large areas of very severe and recent caseating necrosis of tuberculous nature. It was not accompanied by any marked cellular reaction, but there were a few endothelioid and giant cells at the periphery of the caseous areas. In addition there was a mild polymorphonuclear response around some of the areas.

The *kidneys* were congested, and the capsule stripped with ease. In the left kidney was a scar representing an old healed infarct. Scattered throughout the kidney were several minute abscesses, never more than a tenth of an inch in diameter and of such a number that on the single coronal section of the kidney some four or five could be seen (*Fig.* 456). They were unusual in that there was no area of hyperæmia around, and they contained, it was

FIG. 455.—Section of the spleen. (× ⅔.)

thought, some fibrous tissue. Their colour was similar to that of the foci observed in the liver. The pelves were congested, but they and the rest of the genito-urinary apparatus showed no further abnormality. Microscopical examination of the abnormal areas in the kidney showed areas of caseous necrosis, particularly around the convoluted tubules, accompanied by a large mononuclear cell reaction, with a few lymphocytes and polymorphonuclear cells.

All the endocrine glands were normal, as well as the brain and meninges.

At post mortem it was thought that the condition was due to chronic pyæmic infection. No special care was therefore taken to look for evidence of tuberculous lesions in the glands, and these were not saved for microscopical section. If caseation had been present either in the tracheobronchial glands or in those of the mesentery, there is no doubt that it would have been observed, since these were carefully examined macroscopically as a matter of routine. In view of the superficial similarity of the condition to actinomycosis, the mesenteric glands were closely observed.

Bacteriological Examination.—The material taken at autopsy was examined by Dr. E. Sayle, of the Bacteriological Department, Guy's Hospital, whose report we append :—

" Direct examination of films from the caseous material in the liver, spleen, and abscess, stained by the Ziehl-Neelsen method, showed acid-fast bacilli in considerable numbers. This latter feature was particularly striking. Many of the bacilli stained poorly and irregularly.

" Cultures were made directly from all the above sources and gave growths of *Str. hæmolyticus.*

" Suspensions of the material in sterile saline, after it had been previously treated with antiformin, were inoculated on the Loewenstein's medium, and were injected subcutaneously into the groins of guinea-pigs. Growths of tubercle bacilli were obtained about the fourth week, and these gave rise to typical tuberculous lesions in other guinea-pigs which were inoculated.

" The original guinea-pigs also developed tuberculous lesions, and suitable preparations from the glands, spleens, and livers of these were shown to produce tuberculous lesions in a third lot of guinea-pigs. Cultures were also positive.

" Subcultures were made from the original cultures, and of these 10 mg. were inoculated subcutaneously into each of three rabbits. None of these animals died within three months. The organisms also grew well in glycerin broth.

" It is concluded, in view of the fairly profuse growth of this strain, and in view of the absence of pathogenicity for rabbits, that this was most probably a human strain of tubercle bacilli."

FIG. 456.—Section of the kidney. (× ⅓.)

COMMENTARY

This case is of particular interest, for not only is it one of " primary tuberculosis " of the spleen, but an example of tuberculous subphrenic abscess complicating this condition. We believe this to be unique in the literature. Indeed the only case of tuberculous abscess complicating tuberculosis of the spleen is that already mentioned and described by Shands. In an exhaustive review of nearly 900 cases of subphrenic abscess, Piquand (1909) states that 40 only were due to disease of the spleen, usually to suppurating infarcts. None of them was due to tuberculosis. Further, he described 23 cases of tuberculous subphrenic abscess complicating disease of the gall-bladder, liver, kidney, and lung. Not only, then, is subphrenic abscess associated with splenic disease a rarity, but, as a complication of tuberculous splenic disease, not known at all. Piquand does, however, quote Finkelstein (1897), who described 10 cases of tuberculous subphrenic abscess, most of them complicating generalized tuberculous peritonitis, and therefore not of any peculiar interest.

Ochsner and Graves (1933) analysed over 3000 cases of subphrenic abscess, including 50 of their own, and reported that in no case was disease of the spleen responsible, and that none of the abscesses were tuberculous in origin.

Although it would be foolish to talk of the diagnosis of conditions as rare as tuberculous subphrenic abscess, there are certain points in the history of this case that are instructive. First, there was the complaint of pain in the tip of the left shoulder. Subphrenic suppuration often remains undiagnosed for a considerable time, and we think it is worth stressing that shoulder-tip pain without obvious cause, and associated with pyrexia of unknown origin, should always suggest the possibility of subphrenic suppuration. Secondly, the pus obtained at operation proved sterile, and such an event again should suggest the possibility of tuberculous infection, which might have been demonstrated during the life of the patient had culture or animal inoculation been attempted. On the other hand, it is doubtful whether such knowledge would have been of the slightest practical value, although more active treatment in the form of splenectomy might have been attended with success had it been performed sufficiently early. Both Winternitz and Calmette (1936) stress the fact that the disease is limited to the spleen for a considerable time, and that it is limited by its capsule. Reference to the literature on primary splenic tuberculosis shows that the diagnosis has been difficult, and in all but a few cases has been made after operation or, more commonly, after death. Even at autopsy, the cases may present difficulty. Thus Welker and Leger (1938) comment upon a case which at autopsy was diagnosed as multiple neoplastic deposits in the liver, spleen, lungs, and lymph-glands, the final diagnosis of tuberculosis being made only after histological examination. Winternitz, in his review, remarks that the disease is characterized by "rather typical symptoms", although such a statement may perhaps be open to some criticism in view of the rarity of the condition. Pyrexia with obscure splenomegaly is the usual story. Calmette observes that splenic tuberculosis, other than that of the miliary variety, remains almost always latent, and only manifests itself by moderate splenic enlargement. Hickling (1938), who described 2 cases of miliary tuberculosis of the lungs apparently cured by splenectomy, emphasizes the importance of radiological examination of the chest in patients with obscure splenomegaly, while Pether (1937) has described cases of tuberculous enlargement of the spleen presenting splenomegaly, but no other obvious indication of tuberculous infection. Further, Matzdorff (1931) describes a patient whose spleen was enlarged to the umbilicus, and in whom hydatid infection was suspected. Autopsy revealed miliary tuberculosis of the lungs and kidney, while the spleen was caseous and weighed 2950 g.

Shands points out that pain in the upper left quadrant of the abdomen associated with asthenia might be associated with most diseases giving rise to an enlarged spleen, and that it is only histological examination of the spleen that makes the diagnosis possible. On the other hand, Davies-Colley (1938) has observed a patient in whom a spleen removed at operation was diagnosed on microscopical examination as being tuberculous. The patient recovered from the operation, but returned some years later to die of Hodgkin's disease. It is evident that only the discovery of the tubercle bacillus can be accepted as proof of the diagnosis.

Shands has some pertinent remarks to make on radiological diagnosis. He quotes Brunch (1931), who reported calcified nodules in the spleen which were demonstrated radiographically, although the correct pre-operative diagnosis was not made. Shands himself, however, reports 3 cases in which the correct pre-operative diagnosis was made on the presence of opacities below the diaphragm in patients whose predominant symptoms were loss of weight and lassitude, with splenomegaly.

All 3 recovered after splenectomy. Of the 51 cases described by Winternitz, 35 showed large caseous nodules, which might have been demonstrable by X rays. The radiograph taken of the patient described in this paper did not show any opacity in the splenic area.

We have nothing further to add to the discussion on the diagnosis of primary tuberculosis of the spleen. It remains a cause of obscure splenomegaly associated with fever. Splenectomy offers the only hope of cure.

SUMMARY

1. The literature relating to primary tuberculosis of the spleen is reviewed, and explanations are suggested for the vulnerability of this organ to tuberculous infection.

2. A case is described in which tuberculosis of the spleen was complicated by tuberculous subphrenic abscess.

3. The post-mortem and bacteriological findings in the case are given.

4. The clinical history of cases in which primary tuberculosis of the spleen is present is considered, and diagnostic indications are suggested.

We wish to thank Dr. L. Forman, Dr. E. Poulton, and Mr. E. C. Hughes, under whose care the patient successively came, for their permission to publish this case. We should also like to thank Mr. R. Davies-Colley for his kind help and criticism. We are indebted to Miss Nicholson for the care which she has taken with the illustrations.

REFERENCES

BRUNCH, quoted by Shands.
CALMETTE, A., *L'Infection Bacillaire et la Tuberculose*, 1936, 348. Paris.
CAIN, A., MEYER, A., and BRIDGMAN, *Sang*, 1932, vi, 213.
CYMANS, B., *Deut. Zeits. f. Chir.*, 1930, ccxxvi, 110.
DAVIES-COLLEY, R., personal communication.
FINKELDY, W., *Virchows Arch.*, 1931, cclxxxi, 318.
FINKELSTEIN, quoted by Piquand.
FLANDRIN, P., *Sang*, 1931, v, 271.
FORMAN, L., *Proc. Roy. Soc. Med.*, 1937, xxx, 1059.
HICKLING, R. A., *Quart. Jour. Med.*, 1938, vii, 263.
KALBFLEISCH, H., and NOHLEN, A., *Beitr. z. klin. Tuberk.*, 1929, lxxi, 336.
LEBERT, quoted by Kalbfleisch and Nohlen.
LINDEMANN, E. A., *Deut. med. Woch.*, 1912, xxxviii, 1921.
MATZDORFF, F., *Beitr. z. pathol. Anat.*, 1931, lxxxvi, 451.
NIEBERLE, K., *Ergebn. d. allg. Pathol. u. pathol. Anat.*, 1932, xxvi, 711.
OCHSNER, A., and GRAVES, A. M., *Ann. of Surg.*, 1938, xcviii, 961.
PETHER, G. C., *Lancet*, 1937, ii, 1423.
PIQUAND, G., *Rev. de Chir.*, 1909, xl, 336.
RAMEL, E., *Brit. Jour. Dermatol. and Syph.*, 1930, xlii, 1.
SCOTT, H., "Tuberculosis of Men and Lower Animals", *Med. Research Council, Spec. Rep. Series.*
SHANDS, H. R., *Amer. Jour. Surg.*, 1933, xx, 707.
WELKER, J. E., and LEGER, L. H., *Amer. Rev. Tuberc.*, 1938, xxxvii, 354.
WINTERNITZ, M. C., *Ergebn. d. allg. Pathol. u. pathol. Anat.*, 1912, xxvi, 711.

ADOLESCENT DEFORMITIES OF THE ACETABULUM
AN INVESTIGATION INTO THE NATURE OF PROTRUSIO ACETABULI*

By JOHN GILMOUR

HONORARY SURGEON, ROYAL VICTORIA INFIRMARY, NEWCASTLE-ON-TYNE

THE purpose of this communication is to put forward a reasoned consideration of those acetabular deformities which are characterized by an increase in depth. Of these, the condition known as protrusio acetabuli or intrapelvic protrusion of the acetabulum is the best known, and it forms the basis of the present study.

Protrusio acetabuli is such a striking deformity of the hip-joint, that the observer who meets with it for the first time is instantly arrested by it.

The interest of the writer was first aroused early in 1933, when he was confronted with a young patient, a girl of 16 years, who manifested the deformity in both hips to an extreme degree. Inquiries soon elicited the fact that very little was known about its nature, and a research into the available literature on the subject showed that no satisfactory explanation had yet been found.

Investigation shows that cases of protrusion can be divided into two categories: (1) A primary group whose origin has been the subject of much speculation; and (2) A secondary group which results from destructive diseases of the hip-joint, or from injury of the acetabular floor. The principal features of these groups are described, and evidence is adduced to prove that the primary type of protrusion is adolescent in origin, and exhibits all the features of a distinct clinical entity. It will be shown that such protrusions are to be regarded as the extreme degree of a deformity which is graded in severity, and which also occurs in lesser degrees as deep acetabula. The clinical manifestations, radiological features, and pelvimetrical characteristics of these deformities are considered, and their complications are illustrated. A theory of their aetiology is submitted, and a comparison with 'slipped femoral epiphysis' is drawn to show how they resemble this other adolescent deformity. The question of early diagnosis is considered, and the principles which should govern treatment are discussed.

HISTORICAL NOTE

The first recorded example of this deformity was published by Otto, in Germany, in 1824 (*Fig.* 457). The specimen occurred in an anatomical museum, and his catalogued version reads: "This pelvis, from an adult woman, is on the whole fairly normal in size and build; its chief characteristic is the very deep insertion of both femoral heads in the acetabula, so that the floors of the latter protrude far into the pelvis, and are at the same time imperfectly ankylosed." The account goes on to describe each hip in detail: it indicates that the protrusion is so great on the right side that the whole of the neck is within the acetabular margin,

* Based upon a Hunterian Lecture given at the Royal College of Surgeons of England, on January 24, 1936.

and the head cannot be withdrawn from the joint; whilst, on the left side, though the protrusion is not so marked, and only part of the neck is engulfed, the presence of several protruberances on the neck (osteophytes) so limits movement that the excursion of the left knee anteroposteriorly is only 7 in. (cf. *Fig.* 458). The inner condyles of the femora can be separated for a distance of about four or five inches. Hip movements are so restrained that the abdomen and thighs form a right angle in the standing position. The note adds: "The right sacro-iliac symphysis is ankylosed for about one inch, and the right femur appears to be shorter than the left by one inch".

It is now well over a hundred years since Otto described this deformity of the acetabula, and he attributed it to a "form of abnormal gout". Subsequent writers have expressed a wide variety of opinions upon the aetiology of the deformity,

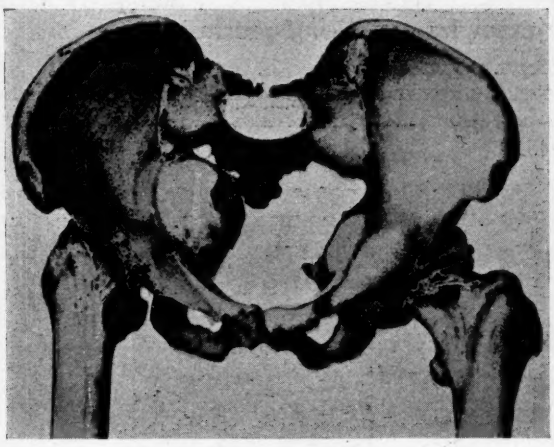


FIG. 457.—Otto's original case.

FIG. 458.—Section illustrating the deformity in an advanced case.

(*Figs.* 457, 458 are taken from Pomeranz's article, and are reproductions from Breus and Kolisko by courtesy of the publishers (*Die Pathologischen Beckenformen*, 1912, iii, Figs. 142, 150. Wien: Franz Deuticke.)

based, no doubt, upon the clinical complexion of their own particular cases. Thus it may be stated briefly that acetabular fracture, some disturbance in the growth of the acetabular epiphyses, specific and non-specific infections of the hip-joint, and the various forms of osteo-arthritis, have all been regarded as causes of this condition. My own belief is that there is a primary phase in which the deformity exists in an uncomplicated state, but that it is more often discovered when osteo-arthritis or other changes have set in. This is supported by the clinical facts met with in the writer's first case, wherein the commencement of osteo-arthritis can be traced in one of her two protruding hips, even although her age was then only 16 years.

An analysis of a group of 37 cases taken from the literature up to 1929, revealed several interesting features which seem to possess particular importance: (1) The deformity was much commoner in females—in the proportion of 30 to 7. (2) Bilateral and unilateral protrusions were almost equal in numbers (17 to 20). (3) Osteo-arthritis was the most frequent complication (in 20 of 26 cases). (4) There was a history of possible joint infection in a third of the cases.

It appears, therefore, that further evidence is required to elucidate the essential problems presented by this deformity, and that consideration must be directed to the following points: (1) The nature of primary protrusions; (2) The relation between the bilateral and unilateral types; (3) The reason why osteo-arthritis is such a frequent complication; (4) The peculiar sex incidence of the deformity; and (5) What part infection plays in the production of acetabular protrusions, and whether the resultant deformity is the same.

In brief, it may be stated that, in addition to injury, almost every known form of joint infection or disease has been blamed for the onset of this deformity.

PERSONAL CASE REPORTS

PRIMARY PROTRUSIONS

Bilateral Protrusions

These cases are described, with their clinical, radiological, and pelvimetrical findings. The first six cases were examples of *bilateral* protrusions.

Case 1.—N. T., female, aged 18 years. Bilateral protrusion.

History.—This girl was brought to the Infirmary, Newcastle-upon-Tyne, by her mother, in January, 1933, because of the increasing prominence of her hips and her shuffling gait. She was then just 16 years old. (*Fig.* 459.)

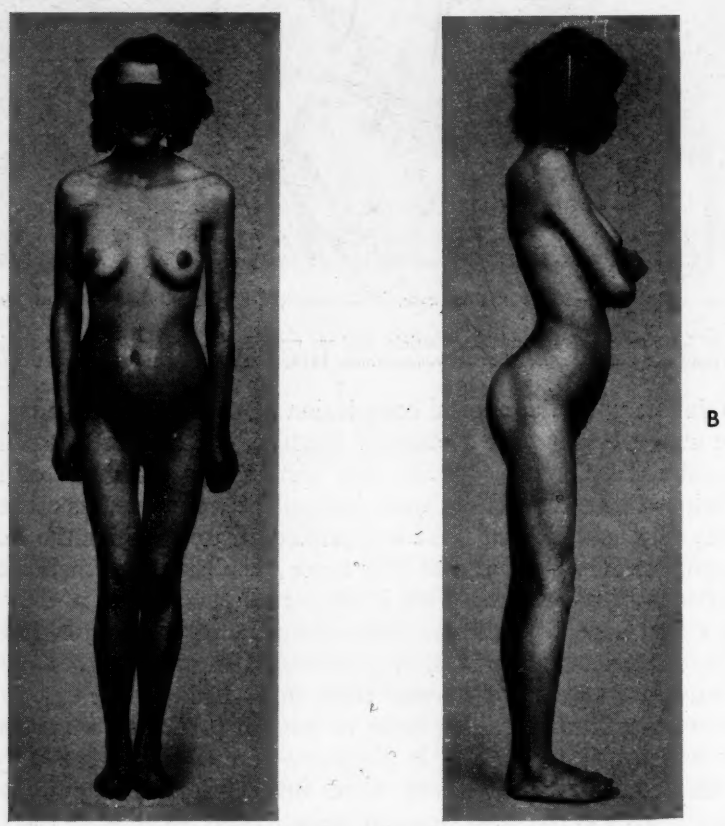


Fig. 459.—*Case* 1. A, Photograph demonstrating the wide pelvic basin and the unnatural approximation of the thighs. B, Showing hyperlordosis of lumbar spine and pelvic tilt.

Six months previously she began to walk with a stiff kind of gait, and this disability had increased. Later she found that her right leg became lame when she walked, but was eased if she flexed her hip. Recently she noticed that towards night, and after exertion, she began to get pain in her hips. Finally, the backward prominence of her buttocks and the increasing hollow of her lumbar spine attracted her mother's notice.

She states that she had most discomfort in the right hip, and that there was an ache in the groin and down the back of the right thigh.

Two months before coming to the infirmary she was taken to her own doctor because menstruation had not commenced. He noticed her deformity and sent her to the infirmary for examination.

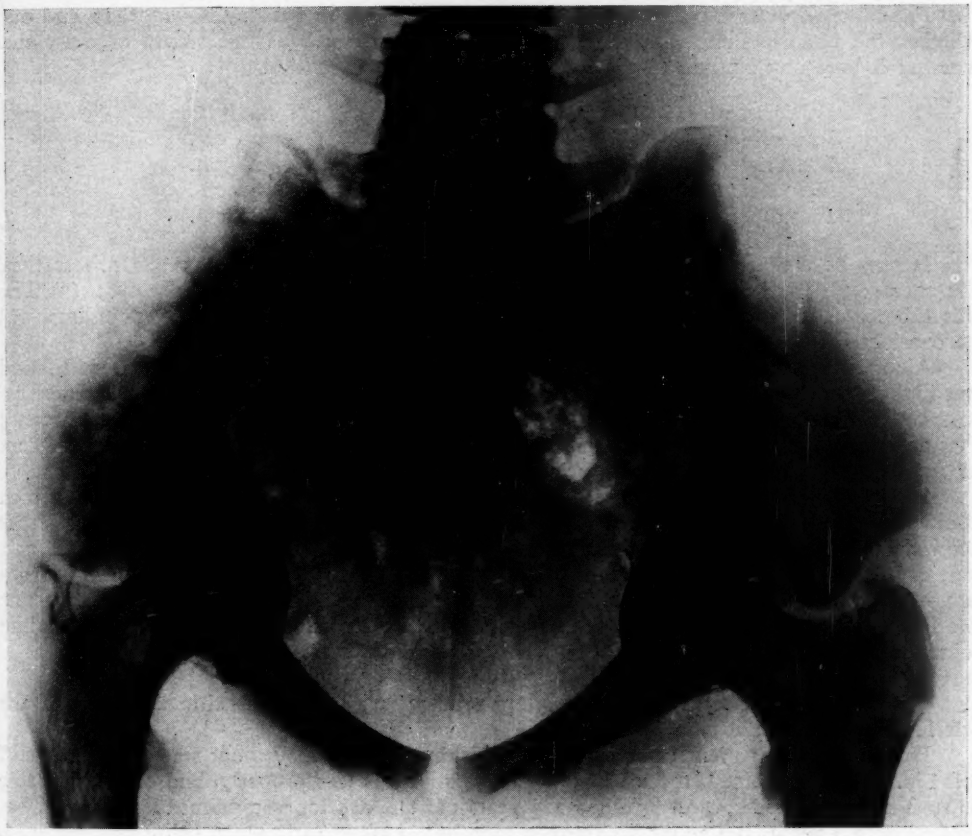


FIG. 460.—*Case* 1. Radiograph showing typical bilateral protrusions of acetabula.

ON EXAMINATION.—Her general health was excellent, but there was an obvious deformity in her hips and lower spine. She walked with a waddling type of gait, the movement being very stilted from the hips. Her buttocks projected backwards, and her lumbar spine was excessively lordosed. The usual rounded prominence of the thighs was absent from the trochanteric region, so that the limbs appeared to descend in a straight line from the iliac crests. The muscles of the right thigh appeared to be somewhat wasted and the adductors were contracted. The movements of both hips were restricted in every direction. The legs were of equal length.

Right Hip: Fixed flexion deformity 20°; voluntary flexion to 60° only (antero-posterior movement 40°). Abduction and rotation absent. Thigh slightly adducted, and could be adducted a little farther.

Left Hip: Fixed flexion 20°; voluntary flexion to 90° (antero-posterior movement 70°). Adduction, abduction, and rotation all reduced.

When both legs were fully separated, the distance between the knees was 8 in., and between the inner malleoli 18½ in. There was no genu valgum or flat-foot deformity.

Pelvis and Spine: The pelvis was tilted forward on the hips to an extreme degree. Both iliac crests were unduly prominent. The median crest of the sacrum was almost horizontal. The lumbar spine compensated for the pelvic tilt by being hyperlordosed. In spite of this, it was not fixed. She could flex it freely to touch her toes, and she could hyperextend it still more at the dorsolumbar junction.

Radiographic Examination (*Fig.* 460).—This demonstrated clearly a bilateral intrapelvic protrusion of the acetabula; the early development of osteo-arthritic changes in the right hip; the forward tilt of the pelvis; and the extreme lumbar lordosis. Shenton's arc was preserved, and there was no evidence of antecedent bone disease.

Pelvic Measurements.—These measurements were taken, in the first instance, to find out whether the bitrochanteric diameter was less than the normal (as one would expect), and whether it bore any relation to the degree of acetabular protrusion.

Diameter	*Patient's*	*Normal Female*
Interspinous	25·0 cm.	26 cm.
Intercristal	29·5 cm.	29 cm.
Bitrochanteric	28·0 cm.	31 cm.
Intertuberous	9·0 cm.	10 cm.

It may be noted in passing that: (1) The bitrochanteric diameter was 3 cm. less than the average; (2) The intercristal measurement was slightly greater than normal; (3) The intertuberous diameter was a little less than usual. The significance of similar findings will be considered in a later section.

Along with these investigations a general clinical examination was undertaken, to find out if there was any evidence of systemic disease. None was discovered. The biochemical tests were all normal: Blood-urea, 33 mg. per cent; Blood-calcium, 11 mg. per cent; Plasma-phosphorus, 3·9 per cent. The Wassermann test was negative. The urine tests were all normal.

SUMMARY.—Clinically, therefore, there was no evidence of general or local disease which could have produced this condition. But it is significant that the condition was bilateral, that the deformity developed during a time when her health was good, and that it developed at a particular period in her adolescence—namely, about six months before the onset of menstruation—and was found to be associated with measurable changes in the pelvis above and below the level of the acetabula. Lastly, the development of early osteo-arthritis in the protruding joint must be noted.

Case 2.—Female, aged 27. Bilateral protrusion, with osteo-arthritic ankylosis of the left hip.

HISTORY.—The patient came to hospital wishing to have movement restored to the stiff left hip. She complained, too, of inability to separate the legs properly, and of being unable to turn the right foot inwards. When 12½ years old she developed a painful left hip and was treated on a Thomas hip splint for thirteen months. Left hip stiff when splint was removed. Further pain three months later was relieved by six weeks' rest. Movement never recovered. Menstruation commenced at the age of 13.

ON EXAMINATION.—

Left Hip: Fixed at 20° flexion, with slight external rotation.

Right Hip: Good movement, but no internal rotation. Pelvis tilted forward, and lumbar spine hyperlordosed.

X-ray Examination (*Fig.* 461).—The left hip showed acetabular protrusion with osteo-arthritic ankylosis; the right hip, acetabular protrusion and some sclerosis of periarticular bone. Shenton's arc was unbroken.

Pelvimetry.—

Diameter	*Patient's*	*Normal Female*
Intercristal	31 cm.	29 cm.
Bitrochanteric	32 cm.	31 cm.
Intertuberous	8 cm.	10 cm.

SUMMARY.—
1. Premenstrual onset of symptoms in one hip.
2. 'Silent' nature of deformity in other hip.
3. Adolescent osteo-arthritis causing ankylosis in the deeper protrusion.
4. Pelvimetric changes.

FIG. 461.—*Case* 2. Radiograph showing bilateral protrusion of acetabula, with osteo-arthritic ankylosis of left hip.

Case 3.—Female, aged 67. Bilateral protrusion. (Bony ankylosis of right hip, osteo-arthritic ankylosis of left hip.)

HISTORY.—Though never laid up in bed, she developed pain in the left hip when 13 years old. Six months later, on holiday, the right hip became affected. Menstruation commenced soon after: the left hip "recovered", but the right hip became fixed and painless. She has had a limp since then. Ultimately she married and had 2 children.

When 54, osteo-arthritis developed in the left hip and is now crippling.

ON EXAMINATION.—

Right Hip: Firmly ankylosed at 45° flexion, with slight abduction and external rotation.

Left Hip: Fixed in flexion. Movement from 30° to 45° only. Thigh adducted and rotated inwards. No abduction or external rotation.

Pelvis tilted forward and lumbar spine fixed in extreme lordosis.

X-ray Examination (*Fig.* 462).—In the right hip, curve of acetabular protrusion, with bony ankylosis; in the left hip, acetabular protrusion with osteo-arthritic ankylosis. Osteophytic deposits were present in the lumbar spine.

Pelvimetry.—

Diameter	*Patient's*	*Normal Female*
Intercristal	31 cm.	29 cm.
Bitrochanteric	31 cm.	31 cm.
Intertuberous	6 cm.	10 cm.

SUMMARY.—
1. Premenstrual onset of hip trouble.
2. Early bony ankylosis follows protrusion (right side).
3. Late onset of osteo-arthritic ankylosis (left side).
4. No history of illness or infection or recumbency throughout life.

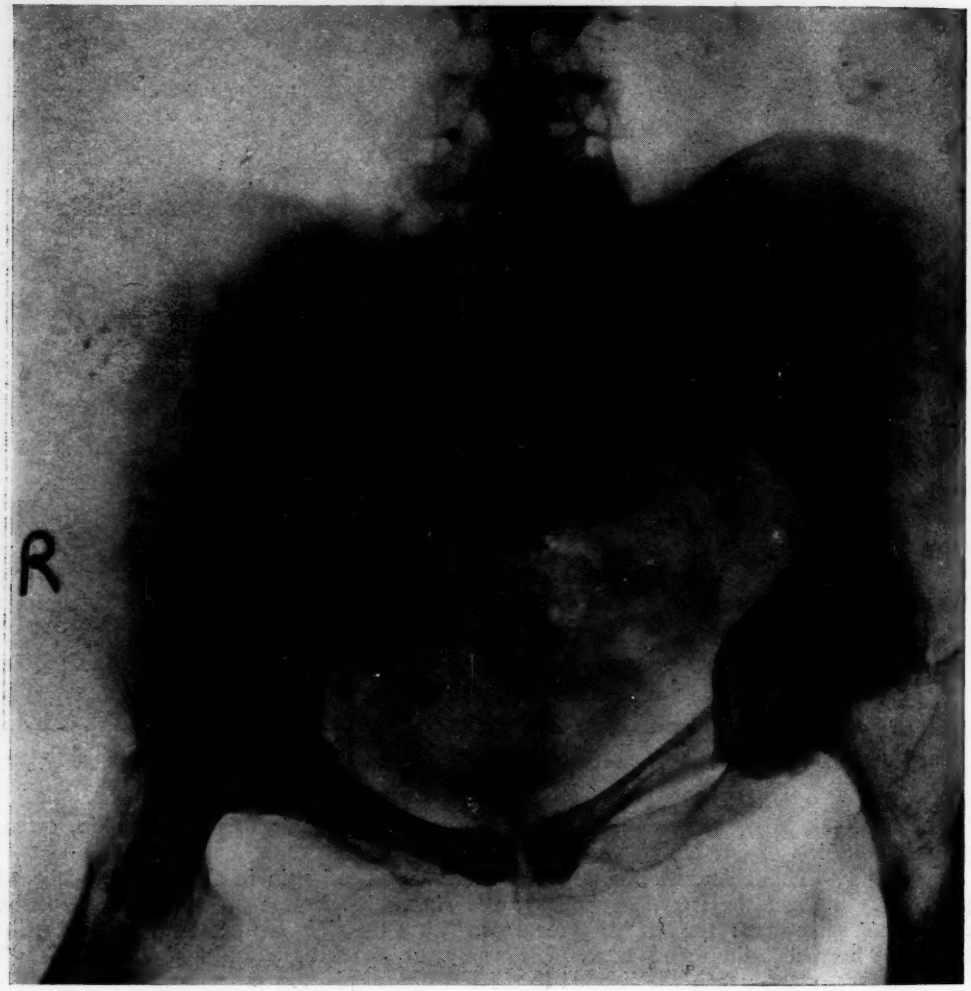


FIG. 462.—*Case* 3. Radiograph showing bilateral protrusion of acetabula, with bony ankylosis of right hip and osteo-arthritic ankylosis of left hip.

Case 4.—Male, aged 60. Bilateral protrusion with osteo-arthritis.

HISTORY.—Came to hospital complaining of left hip in 1935. Developed hip symptoms whilst convalescing after a lung illness in 1916. Lameness followed. Lately crippled with pain; afebrile; confined to bed.

ON EXAMINATION.—

Left Hip: Flexed to 60°. Slightly abducted and externally rotated. Minimal movement painful.

Right Hip: Flexion and extension free. Abduction to 5° and adduction to 15° only. Very little rotation. No pain.

Pelvis tilted forward. Lumbar spine, diminished movement.

X-ray Examination (*Fig.* 463).—Bilateral protrusion. Osteo-arthritic ankylosis in left hip; early osteophytic deposits in right. Shenton's arc normal.

Pelvimetry.—

Diameter	*Patient's*	*Normal Male*
Intercristal	33·0 cm.	28·0 cm.
Bitrochanteric	32·7 cm.	31·8 cm.
Intertuberous	5·0 cm.	8·8 cm.

FIG. 463.—*Case* 4. Radiograph showing bilateral protrusion of acetabula, with marked osteo-arthritic ankylosis of the deeper left hip and earlier osteo-arthritic changes in the right hip.

SUMMARY.—A male patient in whom the symptoms of hip trouble were due to osteo-arthritis. He was not aware of abnormality in right hip nor of its limitations in movement.

Case 5.—Female, aged 35. Bilateral protrusion of mild degree.

HISTORY.—Patient had complained of pain in the right hip and thigh for three months. Discomfort in hip followed a "sore throat". Always appeared after a long walk or heavy day's work, and made her limp. No other illness or infection.

ON EXAMINATION.—Clinical tests of blood and urine were all normal. Both hips showed flexion limited to 100°. External rotation in flexion diminished. Other movements free. No pelvic tilt. Lumbar spine normal.

X-ray Examination.—Mild bilateral protrusions without arthritic changes. Joint space thin. Shenton's arcs intact.

Pelvimetry.—

Diameter	*Patient's*	*Normal Female*
Intercristal	27·2 cm.	29 cm.
Bitrochanteric	28·5 cm.	31 cm.
Intertuberous	8·8 cm.	11 cm.

SUMMARY.—An example of a mild bilateral protrusion in which osteo-arthritic changes have not developed. The absence of hip flexion, pelvic tilting, and hyperlordosis shows that these are secondary static deformities, and not essential signs of protrusions.

Case 6.—Female, aged 25.—Probably an example of mild bilateral protrusion, with traumatic central dislocation of the left femoral head.

HISTORY.—Patient slipped on icy road and fell on her left hip. She sustained a central displacement of the femoral head through a fracture in the acetabular floor.

ON EXAMINATION.—When seen in Newcastle four months later she walked with pain and difficulty. The left hip was flexed to 20°, the thigh was rotated inwards, and the left leg was 2 in. short.

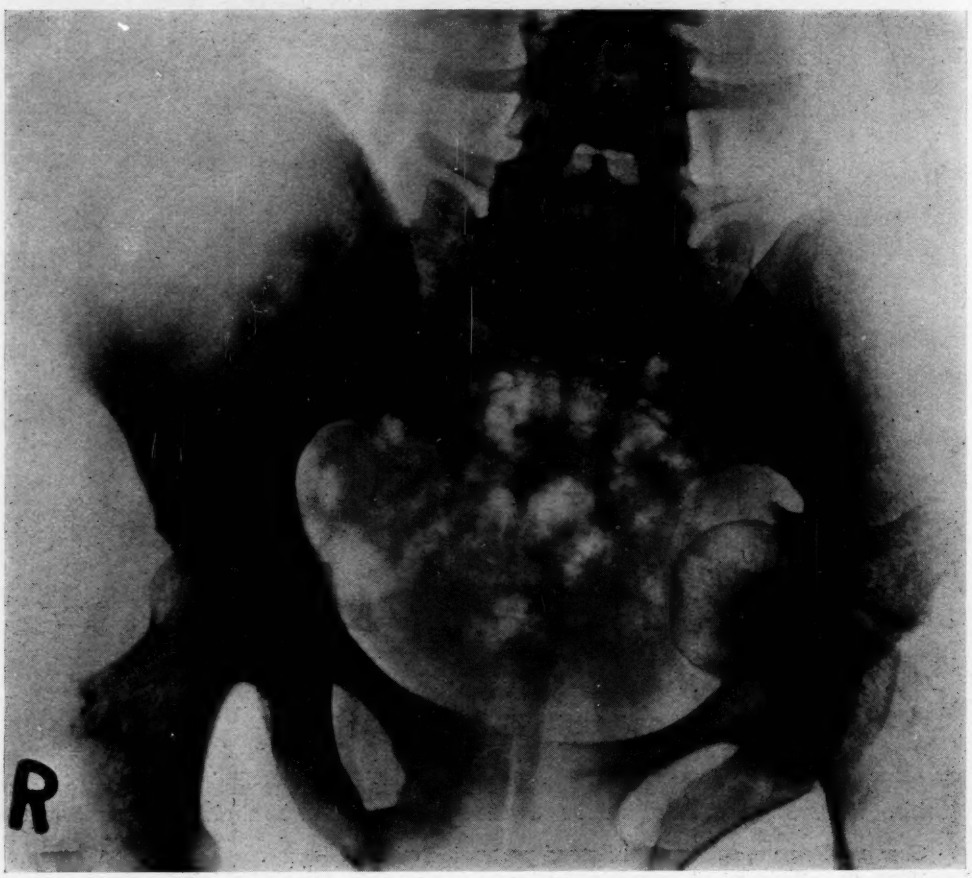


FIG. 464.—*Case* 6. A probable case of bilateral protrusion of the acetabula, complicated by a central dislocation of the left femoral head. Note the very thin floor of the right acetabulum, and its resemblance to *Case* 5.

X-ray Examination (*Fig.* 464).—Right hip: mild acetabular protrusion. Left hip: central dislocation. Femoral head in pelvis, neck in acetabulum. Absence of bony fragments from fractured acetabulum suggest that the floor was very thin, as in protrusions.

Comment.—On X-ray evidence this case is put forward as one of bilateral protrusion illustrating the vulnerability of this deformity to trauma. Brailsford's case (*Fig.* 465) demonstrates a less severe acetabular fracture in another example of bilateral protrusion. Doubt about the primary condition is removed when the other hip is shown to be deformed.

FIG. 465.—Illustration showing the effect of trauma on the right hip. Note the fact that the left acetabulum protrudes into the pelvis, proving that the protrusion deformity is primarily bilateral and the traumatic effect is secondary. (*J. F. Brailsford.*)

UNILATERAL PROTRUSIONS

The following two cases are examples of *unilateral protrusions*, but attention is drawn to the abnormal depth of the opposite acetabula.

Case 7.—Female, aged 64. Developed symptoms of osteo-arthritis in her right hip six years previously, in the wake of a severe attack of gastro-enteritis, for which she was in bed six weeks.

FIG. 466.—*Case* 7. Radiograph showing the combination of a unilateral protrusion (right hip) with a deep acetabulum (left hip). Note that the left femoral head is almost wholly within the bony socket.

ON EXAMINATION.—The right hip was fixed at 30° of flexion, and passive movement was very painful. Her pelvis was tilted forward and her lumbar spine was hyperlordosed and stiff. Left hip free and painless.

X-ray Examination.—Revealed a right-sided protrusion with severe osteo-arthritis, synostosis of the right sacro-iliac joint, osteophytic lipping in the lumbar region, and a deep left acetabulum. Shenton's arcs were unbroken on both sides. (*Fig.* 466.)

Pelvimetry.—

Diameters	*Patient's*	*Normal Female*
Intercristal	37·7 cm.	29·0 cm.
Bitrochanteric	31·0 cm.	31·8 cm.
Intertuberous	5·0 cm.	8·8 cm.

Case 8.—Male, aged 29. Had suffered from left hip stiffness, cramp in the thigh, and an ache in the left groin for a year. No previous illness.

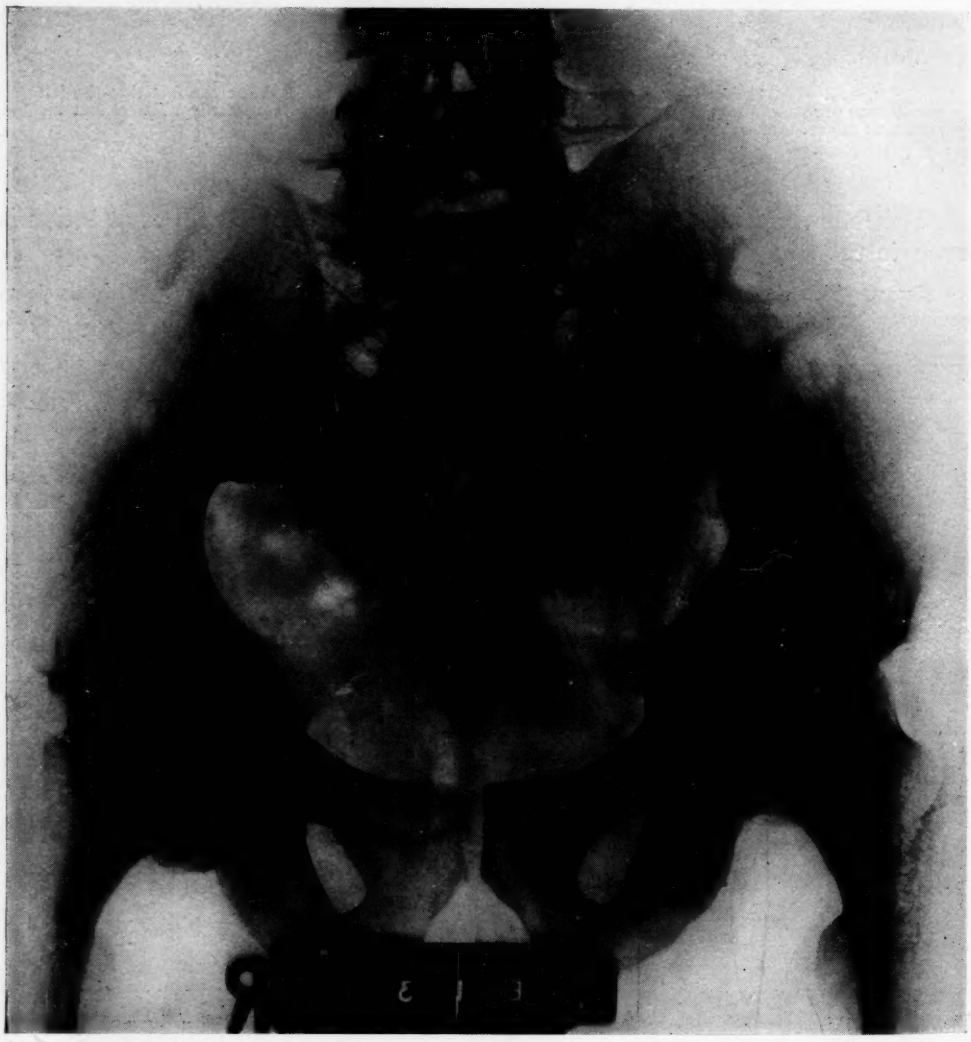


FIG. 467.—*Case* 8. Radiograph showing the combination of a unilateral protrusion (right hip) with a deep acetabulum (left hip).

ON EXAMINATION.—

Left Hip: Movements reduced in range. Flexion to 95°; abduction to 15°; adduction to 15°. Internal rotation, nil. External rotation, minimal.

Right Hip: Flexion to 120°. Other movements free.

X-ray Examination (*Fig.* 467).—Left hip: Protrusion with osteophytic lipping. Right hip: Deep acetabulum. Shenton's arcs unbroken.

Pelvimetry.—

Diameters	*Patient's*	*Normal Male*
Intercristal	20·0 cm.	28·2 cm.
Bitrochanteric	31·0 cm.	31·8 cm.
Intertuberous	5·0 cm.	8·8 cm.

There was an obvious and measurable pelvic asymmetry, the left half being the smaller.

Comment.—These cases illustrate the close relationship of deep acetabulum with acetabular protrusion, and the presence of pelvic measurements typical of bilateral protrusions in both instances justifies the belief that deep acetabulum is a minor grade of the same deformity.

The pelvic asymmetry in *Case* 8 is particularly interesting in that the side with the greater acetabular deformity is also the side in which there is the greater interference with bony growth. This is another link in the evidence that the deformity is closely connected with epiphysial ossification.

DEEP ACETABULA

The next two cases illustrate the occurrence of *bilateral deep acetabula* as a clinical condition.

Case 9.—Male, aged 56, a sea captain. Deep acetabula, with osteo-arthritis. Complained of stiffness in the right hip four years ago, and now has pain and a limp.

ON EXAMINATION.—

Right Hip: Flexion to 90°, from 10° of fixed flexion. Abduction to 15° only; if forced is painful. Adduction to 15°. No internal rotation; free external rotation.

Left Hip: Relatively free and painless.

X-ray Examination.—Both hips show deep acetabula with osteo-arthritic changes, worse on the right.

Pelvimetry.—Pelvic measurement demonstrates bony changes as in protrusions.

Diameter	*Patient's*	*Normal Male*
Intercristal	36·5 cm.	28·2 cm.
Bitrochanteric	31·0 cm.	31·8 cm.
Intertuberous	7·0 cm.	8·8 cm.

Case 10.—Male, aged 60. Deep acetabula without symptoms. The acetabular deformity was discovered accidently in this patient in the course of a urinary investigation. X-ray examination of the pelvis showed two deep acetabula, with an early ring of marginal osteophytes (*Fig.* 468).

ON EXAMINATION.—Some limitation in hip movement. Flexion to 120°. Abduction to 15°. Adduction to 15°. No internal rotation. Free external rotation.

Pelvimetry.—According to type.

Diameter	*Patient's*	*Normal Male*
Intercristal	30·0 cm.	28·2 cm.
Bitrochanteric	31·0 cm.	31·8 cm.
Intertuberous	7·0 cm.	8·8 cm.

Comment.—These two cases illustrate the tendency already observed in protrusions for osteo-arthritis to develop spontaneously in later years. Their pelvic diameters show that these hip-joints are essentially abnormal, even although they remain symptomless for years.

FIG. 468.—*Case* 10. Radiograph showing pelvis with bilateral deep acetabula. Osteo-arthritic changes are developing at margins.

The occurrence of a *unilateral deep acetabulum* completes the range of these deformities :—

Case 11.—Female, aged 63. Unilateral deep acetabulum in left hip with osteo-arthritis. Normal right hip. This woman had had symptoms of osteo-arthritis in the left hip for nearly twelve years.

ON EXAMINATION.—The left hip showed fixed flexion of 15°, with movement to 90°, but no other movements.

X-ray Examination.—Radiography confirmed the presence of osteo-arthritis, but showed that the left acetabulum was abnormally deep.

Pelvimetry.—Revealed a wide intercristal diameter and a narrow intertuberous measurement, with a degree of pelvic asymmetry, the left half being smaller than the right.

Comment.—These findings accord with the main facts of the series and complete the picture which the writer wishes to present.

SECONDARY PROTRUSIONS

From the foregoing illustrations of primary protrusions it is apparent that there is a secondary group in which the deformity is accidental in nature and irregular in type, being the result of destructive disease of the hip-joint, of injury to the acetabular floor, or of bone diseases in which softening occurs, as in

osteomalacia or Paget's 'osteitis' of the pelvis. In each instance the aetiology is known, and the ultimate deformity contrasts sharply with that found in the primary type.

The writer has had 3 secondary cases: the first was due to an acute arthritis of the hip following an attack of erysipelas; the second followed an acetabular fracture; and the third was in a case of tuberculous disease of the hip. One illustration will be given.

Case 12.—Male, aged 27. Tuberculous disease of the left hip. Secondary protrusion. This patient developed hip disease when 16 years old. The joint, now healed, is fixed in flexion and adduction, with a minimal range of passive movement. The limb is 2 in. short.

X-RAY EXAMINATION (*Fig.* 469).—Radiography shows an enlarged acetabular cavity which protrudes into the pelvis with an irregular curve and has also expanded upwards into the ilium. The femoral head is missing and the strut of the neck impinges upon the acetabular roof. The lower part of the pelvis on this side is smaller than normal, growth having been arrested by the disease. Finally, the curve of Shenton's arc is broken. The opposite side of the pelvis and the right hip are normal.

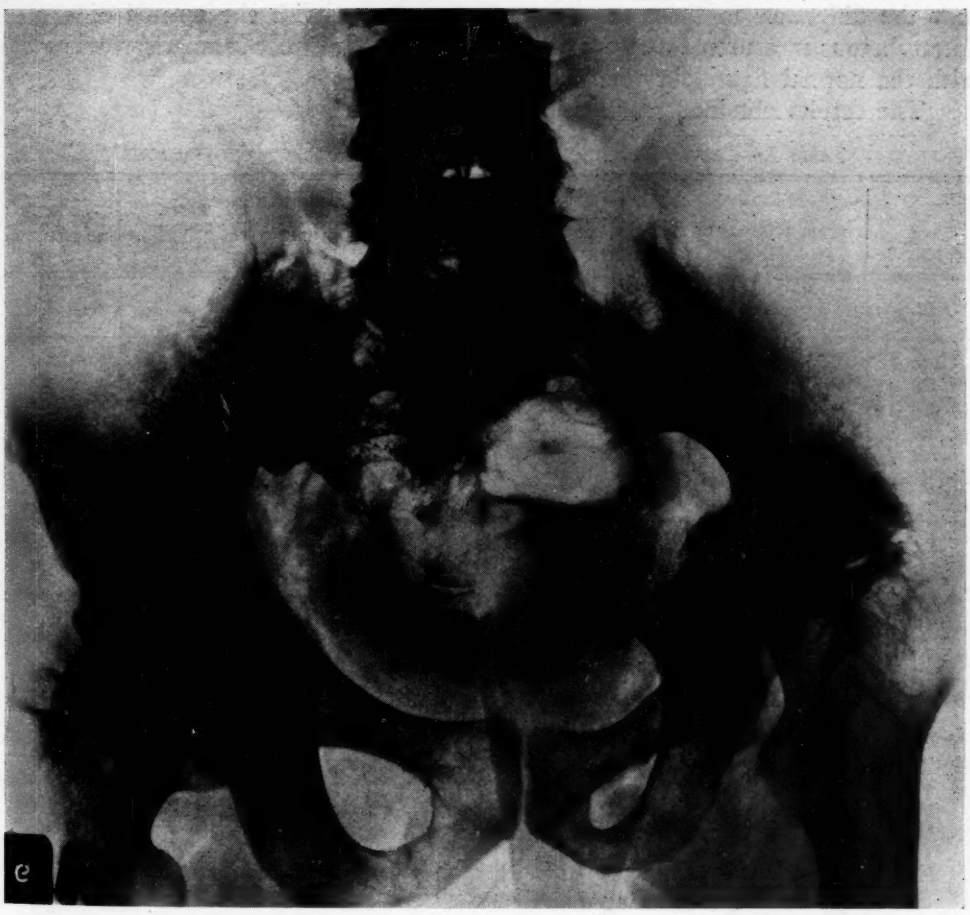


FIG. 469.—*Case* 12. Radiograph of pelvis with both hip-joints. Note the formation of a secondary protrusion on the left side, following destructive changes due to tuberculosis of the hip.

In conclusion, therefore, the features of a secondary protrusion may be summarized as follows :—

1. There is an irregular enlargement of the acetabular floor towards the pelvis, resulting in protrusion.
2. Shenton's line is interrupted.
3. In the inflammatory cases there is some destruction of the femoral head.
4. The affected limb is shortened.

The condition is essentially unilateral in type, and in the writer's experience all the patients were males.

PELVIMETRY IN ACETABULAR DEFORMITIES

Pelvic measurements were first taken to determine whether the bitrochanteric diameter bore any direct relationship to the degree of acetabular protrusion. It was found that the bitrochanteric measurements varied so much from case to case that it was impracticable to compare them with the average bitrochanteric diameter of the normal adult male or female. It was necessary, therefore, to compare these measurements with the intercristal diameter of the patient's pelvis, and to establish how the difference in these measurements contrasted with the normal difference. Intertuberous measurements were also recorded, and a direct comparison was made with the normal figure for this diameter.

The results obtained are set out in *Tables I* and *II*.—

Table I.—PELVIC MEASUREMENTS IN FEMALE CASES OF PROTRUSIONS

	Deformity	Diameters in Centimetres		Difference between Diametres (1) and (2)	Intertuberous Diameter	Relation to Normal
		1. Intercristal	2. Bitrochanteric			
Normal	None	29*	31*	+ 2·0	11·0* cm.	=
Case 1	Bilateral protrusion	29·5	28·0	− 1·5	9·0 cm.	− 2·0
Case 2	Bilateral protrusion	31·0	32·0	+ 1·0	8·0 cm.	− 3·0
Case 3	Bilateral protrusion	31·0	31·0	0	6·0 cm.	− 5·0
Case 5	Bilateral protrusion	27·0	28·5	+ 1·5	8·8 cm.	− 2·2
Case 7	Unilateral protrusion with deep acetabulum	37·7	38·0	+ 0·3	8·2 cm.	− 2·8

* These measurements are given in De Lee's *Principles and Practice of Obstetrics*.

Table II.—PELVIC MEASUREMENTS IN MALE CASES OF PROTRUSIONS

	Deformity	Diameters in Centimetres		Difference between Diametres (1) and (2)	Intertuberous Diameter	Relation to Normal
		1. Intercristal	2. Bitrochanteric			
Normal	None	28·0	31·8*	+ 3·8	8·8 cm.	=
Case 4	Bilateral protrusion	33·0	32·7	− 0·3	5·0 cm.	− 3·8
Case 8	Unilateral protrusion with deep acetabulum	29·0	31·0	+ 2·0	5·0 cm.	− 3·8
Case 9	Bilateral deep acetabula	36·5	31·7	− 4·8	7·0 cm.	− 1·8
Case 10	Bilateral deep acetabula	30·0	31·0	+ 1·0	7·0 cm.	− 1·8

* This figure was the average bitrochanteric measurement obtained in the actual examination of a series of men : other measurements are from Cunningham's *Textbook of Human Anatomy*.

In the normal pelvis the bitrochanteric diameter is greater than the intercristal, the difference being 2 cm. in the female and 3·8 cm. in the male.

In the cases under review there is a noticeable widening of the iliac crests in all but one instance, where the patient was very small. This increase in the intercristal diameter is not associated with a comparable widening of the bitrochanteric diameter. On the contrary, the latter is always relatively small, and often actually less than the intercristal: in one it is equal to it, and in the rest the difference is less than the average for the particular sex involved. The third feature which

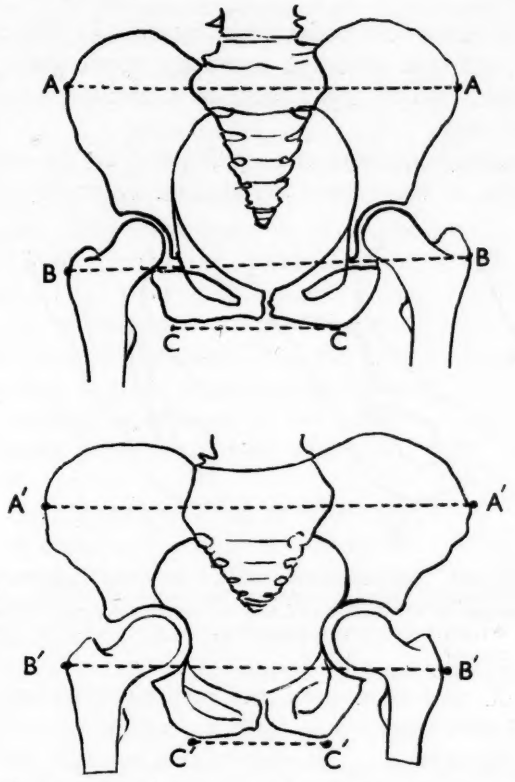


FIG. 470.—Diagrams illustrating the application of pelvimetry to acetabular deformities. The upper figure shows the normal relationship of three transverse diameters. The line AA represents the intercristal measurement, BB the bitrochanteric measurement, and CC the intertuberous measurement. In the normal pelvis, BB is always greater than AA. The lower figure shows how these diameters altered in a case of bilateral protrusion. Here the bitrochanteric measurement, B′B′, is seen to be reduced in relation to the intercristal diameter, A′A′, and the intertuberous diameter, C′C′, is always less than in the normal measurement, CC.

stands out prominently is the marked diminution of the intertuberous diameter. In the female pelves this averaged 3 cm. less than the normal, and in the male 2·8 cm.

There are thus three characteristics which distinguish the pelvimetry of cases with protrusions: (1) The intercristal diameter is apt to be increased. (2) The bitrochanteric diameter is relatively reduced. (3) The intertuberous diameter is always less than normal. The accompanying diagrams illustrate these characteristics (*Fig.* 470).

The *significance* of these common features is threefold: (1) They demonstrate that cases of protrusion and of deep acetabulum belong to the same class of pelvic deformity. (2) They provide a practical test which may be used to make a clinical diagnosis of the condition apart from radiology. (3) They show that there is a close relationship between the growth of the pelvis as a whole, and the cause of this acetabular deformity. This relationship will be considered later on in the discussion upon aetiology.

RADIOLOGICAL CHARACTERISTICS

The diagnosis of acetabular deformities depends in the end upon the radiological examination, and it is therefore necessary to recognize the appearances of the normal acetabulum, and to apply these as a measure to determine the depth of the socket in each case.

Köhler has described in detail the significance of the various 'lines' which characterize the region of the normal acetabulum on an X-ray film. He pointed

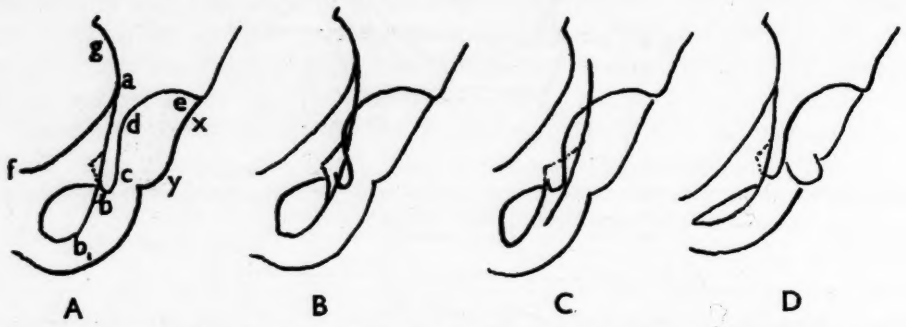


FIG. 471.—Köhler's lines. This illustration is taken from Köhler's treatise on roentgenology, and it depicts the formation of standard 'lines' in relation to the normal acetabulum. The 'tear-drop figure', a, b, c, d, can be recognized in A, where the X rays have been projected exactly through the centre of the pelvis. B, C, and D show the distortion produced under eccentric X-ray projection (*see text*).

out that when the X rays were projected vertically through the midline of the pelvis, these 'lines' were grouped to form a constant pattern, now known as the 'tear-drop figure' (*Fig.* 471, A). He showed that accurate centring on the midline of the pelvis was essential to obtain this figure, and his illustrations show how it is distorted by rays centred over the middle of the hip-joint (B), to the lateral side of the hip-joint (C), and through the mid-pelvis when one side is inclined towards the film (D).

These variations are fundamentally important, for they indicate the need for careful centring on the midline of the pelvis, and they demonstrate the fallacy produced by focusing over the hip-joint itself. Similarly they emphasize the fact that in any attempt to measure acetabular depth, standard conditions must be observed before any reliance can be placed upon the significance of the 'lines'.

The Normal Acetabular 'Lines'.—For the sake of clarity the formation of the 'tear-drop figure' must first be understood (*Fig.* 471, A). According to Köhler the curved line c-d-e marks the contour of the acetabulum. The line a-b-b_1 is produced by the inner wall of the pelvis. The small semicircle b-c joining these two lines, corresponds to the part of the pelvis where the anterior

opening of the acetabular fossa curves round to join the inner wall of the pelvis. The ' tear-drop figure ' is formed by the meeting of these lines, and is a constant feature of the normal acetabular region under central projection of the X rays. Under such conditions, the space between the lines a-b-b_1 and c-d-e, is an indication of the thickness of the acetabular floor.

The Acetabular ' Lines ' in Cases of Deformities.—The position of these lines and their relation to one another may be utilized to measure acetabular depth, provided the rays have been properly projected at right angles to the midline of the pelvis. This was done by making a tracing of these lines from a number of published radiographs, and the results obtained are of primary importance, proving, as they do, the various gradations of this deformity.

A Typical Protrusion.—The first illustration (*Fig.* 472) is a tracing of Frölich's case of bilateral protrusion. Here the semicircular curve of the acetabular line, c-d-e, sweeps across the line of the pelvic wall, a-b-b_1, and is projected within the curve of the pelvic brim (line f-g). The curve of the femoral head fits the acetabular cup very closely, and its summit is projected within the pelvic line. The joint space is thin, but even, and the normal depression of the acetabular fossa is not seen. There is no ' tear-drop figure '. The curve of Shenton's arc is preserved intact.

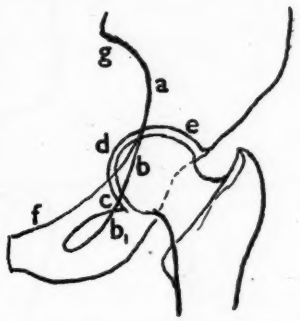


FIG. 472.—This demonstrates the application of Köhler's lines to a typical example of acetabular protrusion (*see text*).

The Features of Deep Acetabulum.—For the purpose of this investigation, cases of unilateral protrusion were selected, and tracings were made of the contralateral hip to determine whether it was abnormally deep (*Fig.* 473).

Fig. 473, A is the contralateral hip in Cary and Bernard's first case of unilateral protrusion. Here the acetabulum *is* deeper than normal. The lines c-d-e, a-b-b_1, and f-g all converge and fuse at the acetabular floor, and the ' tear-drop figure ' is reduced to a diminutive ' candle flame '. The joint space is normal, and the femoral head just passes under the bony roof of the socket.

Fig. 473, B is the contralateral hip of Doub's Case 7. Here the acetabulum is deeper than in *Fig.* 473, A. The line c-d-e crosses the line a-b-b_1, and touches the line of the pelvic brim, f-g. The ' tear-drop figure ' appears to be reversed, and the drop is replaced by a tiny cone. The joint space is preserved, but the femoral head is entirely within the bony roof.

Fig. 473, C is a further illustration (Doub's Case 3), but it is complicated by osteophytic deposits. Here again the lines fuse at the deeper part of the curve, and the head lies within this curve.

Fig. 473, D is a particularly interesting example of bilateral deep acetabula (Doub's Case 4).

Fig. 473, E is added because it illustrates the first degree of acetabular protrusion (Reed's case). Here the line c-d-e crosses the lines a-b-b_1, and f-g, and falls therefore within the pelvic cavity. The ' tear-drop figure ' is absent, and the head lies within the bony cup.

Conclusions.—These studies show that protrusions and deep acetabula are manifestations of the same deformity, varying only in degree. There are therefore

four grades: (1) Bilateral protrusions; (2) Unilateral protrusions with deep acetabulum; (3) Bilateral deep acetabula; (4) Unilateral deep acetabulum with normal acetabulum.

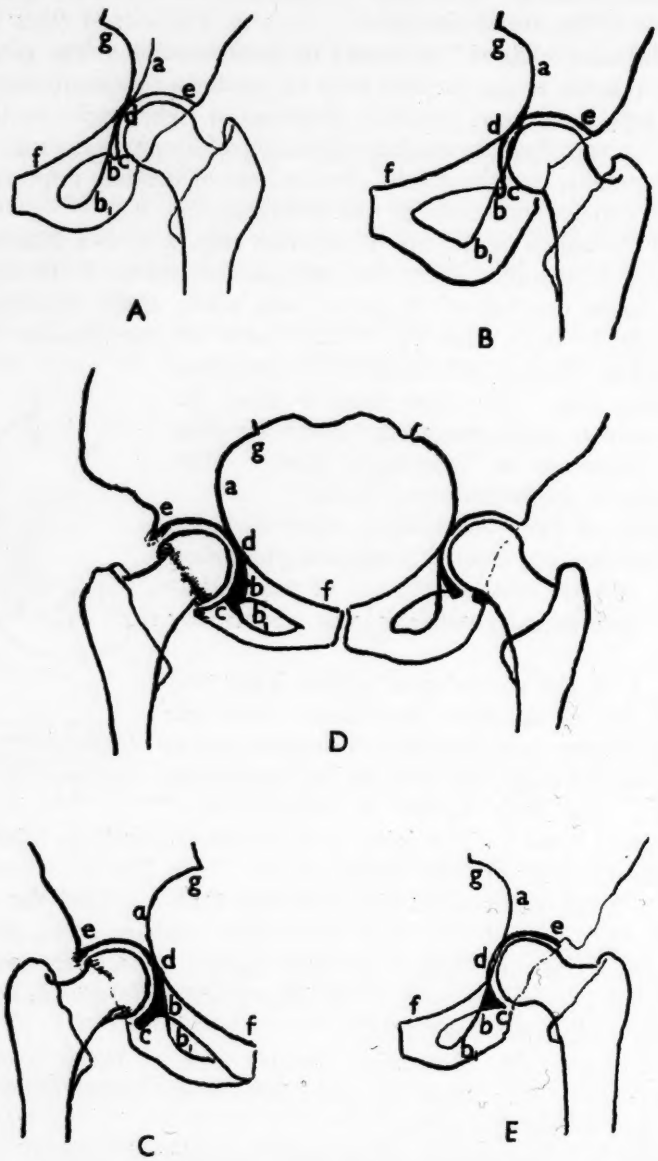


FIG. 473.—The gradations of acetabular depth are revealed by the examination of the radiographic 'lines'. A, E, C, and D show deep acetabula, and in B there is a mild degree of protrusion (*see text*).

Such gradations imply that the origin of the deformity is related closely to the growth of the pelvis as a whole.

Gradations of Acetabular Deformity.—The radiological features of these acetabular deformities are therefore the 'foot-rule' by which they may be

measured and classified. Applying this test to the personal group of cases and to the 35 cases which have been recorded in surgical and radiological literature during the last ten years, it is interesting to find that both sets of cases illustrate the various grades of deformity, and that the incidence of these grades is roughly proportional (*Table III*). These facts bear significant testimony to the truth of the thesis advanced in this paper.

Table III.—RADIOLOGICAL ANALYSIS

TYPE OF DEFORMITY	PERSONAL CASES			MODERN CASES FROM LITERATURE		
	Females	Males	Total	Females	Males	Total
1. *Primary* :						
Bilateral protrusions	5	1	6	13	7	20
Unilateral protrusion with deep acetabulum	1	1	2	6	0	6
Bilateral deep acetabula	0	2	2	3	2	5
Unilateral deep acetabulum with normal hip	1	0	1	2	0	2
TOTALS	7	4	11	24	9	33
2. *Secondary* :						
Unilateral protrusion with normal hip	0	3	3	0	2	2

FUNDAMENTAL FEATURES

The evidence so far adduced justifies the following fundamental conceptions of these acetabular deformities :—

1. It is possible to differentiate between protrusions which are primary growth deformities, and those which are secondary.

2. *Secondary protrusions* are due to destructive disease of the hip, or to trauma damaging the floor of the acetabulum. They are therefore essentially unilateral in incidence and the opposite hip is not involved in the deformity. In the personal series 3 cases belong to this type, and it is noteworthy that they all occurred in males.

3. *Primary protrusions*, on the other hand, are all related to the development of the bony pelvis and are not due to destructive disease or to hip trauma. They are commonly bilateral, and preponderate in females. They show a marked tendency to osteo-arthritic degeneration.

4. Primary protrusions are to be recognized as the extreme degree of an acetabular deformity, which is adolescent in onset and characterized by an increase in the depth of the acetabulum, with associated changes in pelvimetry.

5. Bilateral protrusions may vary in depth, and in unilateral protrusions the opposite hip is always deeper than normal. Thus the *relationship of bilateral and unilateral primary protrusions is clearly established*—both are examples of an acetabular deformity which is essentially bilateral in incidence, though varying in degree.

6. *Deep acetabulum* is recognized as a minor grade of the primary deformity, and as such might well be named ' coxa profunda '. Its main clinical significance lies in the fact that it accounts for many of those adult hips which undergo

spontaneous osteo-arthritic degeneration in later years. Bilateral and unilateral types also occur.

7. *Pelvic asymmetry* is always a feature when the degree of acetabular deformity is unequal on each side.

THE CLINICAL ASPECTS OF PROTRUSIONS

The clinical features of primary acetabular deformities have been studied in 44 cases (11 personal and 33 taken from recent surgical and radiological literature). They are best seen in cases of well-developed protrusions, since the lesser grades of acetabular deepening do not usually cause clinical symptoms until degenerative changes set in.

For practical purposes three clinical types of the deformity may be recognized: Type 1, deformities without secondary arthritic changes; Type 2, deformities with unilateral arthritic changes; Type 3, deformities with bilateral arthritic changes.

Type 1. Deformities Without Arthritic Changes (9 Cases).—This group is important because it illustrates the features of the uncomplicated deformity. Its recognition has been mainly accidental, and due to radiographic examination consequent upon the development of pain and stiffness in the hip (irritative changes), or to the occurrence of local trauma, such as falls upon the joint. There is considerable evidence, however, that many of these patients were previously aware of some abnormality in the hip which limited particular movements, affected gait, or produced an alteration in physical contour.

It is apparent, therefore, that in the early phase (1) the deformity is a painless one, and that (2) the initial signs arise from the limitations set upon hip movement by the deep insertion of the femoral head within the acetabulum.

THE ABSENCE OF PAIN: ITS SIGNIFICANCE.—Clinical records show that the uncomplicated deformity remains painless until degenerative or irritative changes occur, and as this may not happen for years, it may be called a 'silent deformity'. In practice this has usually meant that the patient has also preserved a discrete silence concerning any restricted movement of her limbs.

Similarly, in cases with unilateral symptoms, doubt has rarely been focused upon the opposite hip, for it has usually been assumed by patient and doctor alike that this was normal. The records show that this is never true in the case of protrusions, and that it is important to examine the 'silent' hip for evidence of acetabular deepening. The symptomless hip is, in fact, the link between Type 1 and Type 2, and the proof that deformity precedes osteo-arthritic changes.

THE SIGNS OF THE DEFORMITY.—

1. *Limitation of Hip Movement.*—This varies in proportion to the depth of the acetabulum. In extreme protrusions, the neck lies within the cotyloid margin, and movements are greatly restricted by bony contacts. In less severe cases, abduction and rotatory movements are chiefly curtailed, but flexion may be reduced in range, and there may be a measure of fixed flexion deformity preventing full extension of the thigh.

2. *Pelvic Tilt* (Secondary Deformity).—Fixed flexion of the hip is always accompanied by a forward tilt of the pelvis, and this is very noticeable in the wide ilia of protrusions.

3. *Hyperlordosis of the Lumbar Spine* (Secondary Deformity).—This is a compensatory change due to the forward tilt of the pelvis. Patients refer to their "hollow backs", and are very conscious of the backward projection of their buttocks.

4. *Gait.*—In a bilateral protrusion with limited hip movement, pelvic tilt, and hyperlordosis, the gait is peculiar. It has a stilted appearance and buttock movement is prominent.

5. *Minor Disabilities.*—In less well-developed deformities patients are apt to notice certain restrictions in movement more particularly. Thus one patient knew that she could not turn her leg inwards. Another discovered that she could not sit with her legs crossed, and a third that she could not do the frog kick when learning to swim.

It is clear, therefore, that the slightest limitation of movement may be significant in the detection of this graded deformity.

Type 2. Deformities with Unilateral Arthritic Changes (19 Cases).—This group is characterized by the development of progressive stiffness and pain in one hip, commonly the deeper protrusion, whilst the other joint remains silent, although radiographic examination will demonstrate the presence of acetabular deepening. The onset of symptoms may be gradual or date from an injury.

In the present series 5 cases exhibited the onset of spontaneous osteo-arthritis and 4 followed upon falls upon the hip. In the remaining cases a variety of conditions preceded the appearance of arthritic changes. These include: pregnancy followed by a phlebitis of the affected leg, an uncomplicated confinement, an attack of bronchial catarrh, of gastro-enteritis, and of acute cholecystitis, a history of typhoid fever, multiple arthritis associated with dental sepsis, a true polyarthritis, and a chronic gonococcal arthritis.

The only conclusion to be drawn from these facts is that the protruding hip is particularly vulnerable to trauma, to prolonged recumbency, to superimposed infections, and in the presence of remote inflammations. Age cannot be held to be responsible for this proclivity, for, in the cases under review, osteo-arthritic changes were noted in every decade from the second to the sixth.

Type 3. Deformities with Bilateral Arthritic Changes (16 Cases).—Cases of this type appear to be as numerous as those with unilateral symptoms. Arthritic changes came on insidiously in the majority, but in several the operation of precipitating causes could be traced.

The patients have usually complained of one hip at a time, and in several instances one has ceased to be painful because of osteo-arthritic ankylosis. The degree of osteo-arthritis is usually well marked in both hips, and both exhibit very definite flexion deformity with pelvic tilt and lumbar lordosis.

Secondary arthritic changes in the sacro-iliac joints and in the lumbar spine are common, and the knees may show early degenerative changes. For this reason, some patients are seen with active symptoms in these associated joints, and it is important to ascertain that the acetabular protrusions have been primarily responsible. Similarly it is necessary to differentiate this condition of multiple osteo-arthritis from a true polyarthritis, which is infective in origin, but which may perchance overtake an individual already affected with primary protrusions.

In the late stages, cases of Type 3 correspond exactly with the description given by Otto, and the type might therefore be called the 'Otto' type or 'Otto' pelvis.

Summary of Clinical Facts.—The facts may be set out very briefly as follows :—

1. Of 44 cases, 9 (Type 1) had no arthritic changes, 19 (Type 2) had changes in one hip, 16 (Type 3) had changes in both hips.

2. The tendency to degeneration is very marked.

In 67 protruding acetabula	14	showed no degeneration
53 of 67 (or over 80 per cent)	18	showed early osteo-arthritis
	29	showed marked osteo-arthritis
	5	showed ankylosing osteo-arthritis
	1	showed bony ankylosis
In 18 deep acetabula	6	showed no degeneration
12 of 18 (or 66 per cent)	8	showed early osteo-arthritis
	4	showed marked osteo-arthritis

3. The sex incidence of acetabular deformities reveals a preponderance of each grade in the female.

	Female	*Male*
Deeply marked protrusion	29	15
Protrusion	17	6
Deep acetabula	13	5
	59	26

4. There is a definite clinical history dating from adolescent years in 10 of these 44 cases. These were all female, and they were distributed in each of the three clinical categories, thus linking each type with a common origin.

COMPLICATIONS

Two complications call for special consideration—namely, osteo-arthritis and aseptic bony ankylosis.

1. Osteo-arthritis.—The great frequency of osteo-arthritis has been noted. This subject merits separate treatment, and the writer has therefore dealt with this question in another article in this number of the JOURNAL (p. 700).

2. Aseptic Bony Ankylosis.—The records of *Case* 3 suggest that an aseptic process may sometimes lead to a true bony ankylosis in cases of pronounced acetabular protrusion. The explanation of this occurrence is not yet clear. It may be that the deformity developed more rapidly than usual, and that there was a literal 'seizing up' of the articular surfaces as the femoral head moulded itself into the deepening socket.

The ankylosis which sometimes develops in a case of ununited fracture of the femoral neck between the capital fragment and the socket, bears a possible resemblance to this phenomenon, and can only occur when the fluid buffer which separates these surfaces has been forcibly ejected from between them.

There is certainly nothing in the clinical history of this case to indicate the occurrence of any joint infection which might have caused such an ankylosis.

AETIOLOGY

The various characteristics of these acetabular deformities point to the evolution of some change which has overtaken the primary epiphyses during adolescence. This change must be one which renders the acetabular floor more plastic, so that

it yields to the pressure of the femoral head; it must likewise be responsible for the relative increase in width of the iliac crests; and it must enable us to explain the lack of development and incomplete separation of the ischia, and that measure of pelvic asymmetry which occurs in cases of unequal acetabular deformity.

The only satisfactory explanation is one based upon some alteration in the normal physiological development of adolescent epiphyses.

Theory.—It is now suggested that the change which is responsible for these features is an acceleration in the rate, and an advancement in the timing, of primary epiphysial ossification—a process which may be defined as the " premature acceleration of primary epiphysial ossification ".

Such a phenomenon would account for the various features of the deformity:—

1. Its manifestation in the Y-shaped epiphyses of the innominate bones would convert the normally resistant cartilage of the acetabular socket into young vascular bone—a tissue ill adapted to resist stress and likely to undergo protrusion-deformity in consequence of the rapid increase in weight which takes place in adolescence, and which must be transmitted through the hip-joint when the individual stands or walks about.

2. Its appearance in the primary epiphyses which rim the iliac crests would result in a phase of rapid growth in the iliac alæ, and this would be sufficient in itself to account for the increased measurement between the iliac crests.

3. The lack of ischial development, the narrow intertuberous diameter, along with the measure of pelvic asymmetry which occurs in cases of unequal acetabular depth, are to be explained as the remoter consequences of the deformity, in that this must complicate the processes of growth which take place from the acetabular epiphyses.

Normally there is an uninterrupted radial growth of bone from these epiphyses. This must be disturbed as this growth-focus undergoes distortion, and growth must be impeded in proportion to the measure of the interference caused by the deformity.

Now the ischium is the largest of the three elements of the innominate bone which enter into the formation of the acetabulum, and because it forms the floor of the socket it is the part which suffers most from the thrust of the femoral head. It follows, therefore, that the ischium is the part which shows the greatest measure of arrested growth, and this explains why the intertuberous measurement is always less than normal.

The occurrence of pelvic asymmetry is in exact concord with this explanation, since it has been shown that the smaller innominate bone is always the one with the greater protrusion.

Discussion.—This theory cannot be substantiated by exact proofs, for histological material cannot be removed from suspected epiphyses in otherwise healthy individuals, and there is as yet no experimental proof available to demonstrate the part played by endocrines upon epiphysial fusion.

A. There is, however, evidence of a collateral kind which supports the view that this deformity is due to an aberrant physiological process.

1. For example, there appears to be an alteration in the *rhythm of adolescent development* in cases of protrusion.

Normally the passage from childhood to puberty, from puberty to adolescence, and from adolescent to physical maturity, is characterized by an orderly sequence of events:—

Stage 1: Growth in length in late childhood.

Stage 2: Development of external sex characteristics in puberty.

Stage 3: A period of rapid growth in length, followed by the physical development of organs and tissues generally.

Stage 4: The establishment of sexual functions in adolescence (menstruation; spermatogenesis).

Stage 5: Further longitudinal growth arrested by the closure of the primary epiphyses.

Stage 6: The slow development of bony structure from secondary epiphyses until final fusion takes place. Muscular development accompanies this. Maturity is attained.

This sequence in rhythm is changed in cases of protrusion. In 3 of the writer's cases the observation was made that the signs of the deformity had preceeded the onset of menstruation. This implies that "the phase of rapid growth in length" (Stage 3) was followed immediately by "the premature acceleration of epiphysial closure" (Stage 5), and that "the signs of sex function—menstruation" (Stage 4)—only appeared at a later date.

Such a rapid sequence of the processes of epiphysial growth and of epiphysial fusion must necessarily throw a considerable strain upon the tissues in these regions, for these two phases of chondral ossification are usually separated by a period of several years, during which bony consolidation is never in jeopardy. In the absence of this beneficent interval, the epiphysial regions must be in a state of great cellular activity, and this must result in the formation of a relatively large amount of young vascular ossifying tissue and culminate in the replacement of the epiphysial plate by a layer of similar tissue.

2. The peculiar *sex incidence* of the deformity also suggests a physiological explanation, for it is a well-established fact that in females ossification and epiphysial fusion and other adolescent changes precede those in males by one or two years. The impact of the phenomenon which this theory postulates would naturally occur, therefore, earlier in girls than in boys, and would, in consequence, predispose them more than boys to the risk of developing this deformity.

B. Two views of a different aetiology have been aired in the literature:—

1. *Osteochondritis* has been put forward as a possible cause, but there does not appear to be any evidence in support of this. It should be remembered that osteochondritis affects small endochondral bones and that it is not a malady of epiphysial cartilage. Furthermore, it occurs at an earlier stage in life than protrusions, and its radiographic features are marked by irregularities in bony texture and outline which are not found in cases of protrusions.

2. Schaap has argued recently in favour of a *congenital origin*. He was impressed by its tendency to bilaterality and by its sex incidence, and compared it with congenital dislocation of the hip. Apart from the fact that no one has ever reported the occurrence of a protrusion in infancy or early childhood, it is difficult to imagine how the broader female pelvis can be considered responsible for the development in utero of two such extremely opposite deformities of the hip-joint.

C. Sticking to the anatomical features of this deformity, its bilaterality and gradations, and the associated pelvic characteristics, we are obliged to conclude that the underlying condition must be one affecting the growth of the primary epiphyses of the innominate bones. Adaptive changes in the femoral neck and

the preservation of Shenton's arc in all cases of uncomplicated protrusions are features which support this thesis.

Schaap showed that in protrusions there is a mild degree of coxa vara. Assuming that the normal femoral angle in the female is 125°, he found, in examining 36 cases of protrusions: 12 joints with a femoral angle of 110°–113°; 22 joints with a femoral angle of 115°–120°; and only 2 joints with a femoral angle of 122°–125°.

This combination of a mild coxa vara with an unbroken Shenton's arc indicates a *reciprocal adaptation* of the femoral epiphysis to the deeper acetabulum, whereby the femoral head, guided by the acetabular roof into the deepening socket, gradually assumes a lower and more vertical plane to the axis of the femoral neck, the limit of descent being determined by the final depth of the acetabular protrusion. *Such a reaction can only take place during adolescent growth, and is, in fact, merely an exaggeration of the normal process which occurs during the evolution of the hip-joint between puberty and adolescence.*

D. The last piece of evidence that protrusions are adolescent in origin which will be adduced, is the association which exists between this deformity and adolescent or epiphysial coxa vara.

The close association of the acetabular and capital epiphysial cartilages cited in the foregoing paragraph, and the fact that both fuse at the same time, suggests that they may both manifest phases of abnormal epiphysial evolution under certain physiological conditions.

FIG. 474.—Radiograph of Brailsford's case, showing the association of an acetabular protrusion with a slipped upper femoral epiphysis.

The occurrence of both deformities in one patient would be regarded as evidence of a common aetiology, and I am indebted to Mr. James Brailsford for his kindness in sending me a print of a radiograph which illustrates an acetabular protrusion in one hip and a slipped femoral epiphysis in the other (*Fig.* 474). The clinical history of this case is as follows:—

"At the age of 11 this girl developed a limp and an ache in the left hip. Treatment was by abduction frame with extension, followed by a plaster spica.

"During convalescence, a year later, her right hip gave way, and she was again treated on an abduction frame with the limbs in very wide abduction.

"On recovery, she had a stiff, painless left hip and a movable right hip with shortening."

The illustration shows a left-sided protrusion with osteo-arthritic ankylosis and a typical right-sided slipped femoral epiphysis with a deep acetabulum.

Evidence of a similar association of the two deformities occurs in cases of advanced renal rickets, and though here a different pathology is responsible, it serves to illustrate that acetabular and capital epiphyses are equally susceptible to deforming influences.

A wider comparison of the features which characterize slipped epiphyses and acetabular protrusions (*see Table IV*) reveals so many points in common as to leave no room for doubt that these conditions follow the same fundamental epiphysial changes, the site of deformity in any particular case being dependent upon such factors as body-weight, physical stresses, and, possibly, accidental trauma.

Table IV.—Comparison of Adolescent Slipped Epiphysis with Acetabular Protrusions

Special Features	Adolescent Slipped Epiphysis	Acetabular Protrusion
Age of onset	In early adolescence. One to two years earlier in girls (Willis)	In early adolescence
Distribution of deformity	Unilateral and bilateral 15 per cent (Key)	Bilateral and unilateral
Degree of deformity	Various degrees of "slipping" (Perkins)	A graded deformity. Protrusions and deep acetabula
Associated changes in other component part of joint	Acetabular deepening varying with early treatment	Mild degrees of coxa vara (Schaap)
Epiphysial changes	1. Pre-slipping (early) 2. Premature epiphysial fusion	"Premature acceleration of epiphysial ossification"
Evidence of metaphysial plasticity	Shortening and thickening of femoral neck	Inward protrusion of acetabular floor
Sex incidence	Commoner in males	Commoner in females
Endocrine disturbances	Often recorded; e.g., "adipose changes"	"Alterations in rhythm of adolescent development"

The one point of contrast between these deformities is the preponderance of protrusions in females and of slipped epiphyses in males. This suggests that during adolescence the acetabular epiphyses are more susceptible to deforming influences in females, and the capital epiphyses in males. This may be due to the wider female pelvis, and to the higher angle of the male femoral neck, or to a failure of both epiphyses to fuse synchronously, as they should do, causing one or other to carry an unequal strain. It seems likely that the sex differences in the skeleton play an important part in determining the site of deformity.

DIAGNOSIS

The diagnosis of acetabular protrusions rests upon the recognition of those signs of the deformity which have been described, and upon its radiographic features. It is unnecessary to recapitulate these, but since the deformity develops during adolescence, it is pertinent to ask whether its onset occasions any symptoms by which its earlier stages might become known. Prevention of the deformity would then become the aim of treatment.

Is Epiphysiolysis the Precursor of Acetabular Deformity?—In a radiological publication entitled *Epiphysiolysis*, Bernstein and Arens described epiphysial changes which they found in young persons without deformity, who had complained of discomfort in various epiphysial regions. These were characterized by a widening of the chondral line and a " wooliness " of the adjacent bony substance, which they considered to be the result of a constitutional disturbance originating in some change in the glands of internal secretion. It is surely significant that these changes resemble in radiographic detail those described by Brailsford and others in the ' pre-slipping ' stage of epiphysial coxa vara.

Similar changes are sometimes seen in the acetabular epiphyses of growing adolescents who are brought to hospital complaining of an aching hip, discomfort after exertion, or a tendency to limp when fatigued. The affected joint is found to be mildly irritable, and it arouses the suspicion of early hip disease. In such a case, the patient looks in good health, and no tuberculous focus is found on X-ray examination. Instead, the acetabular epiphyses have a ' fluffed out ' appearance, looking wider and hazier than usual, and the adjacent bone is ' amorphous ' in texture.

Recovery usually follows a test period of rest in bed, but the writer has known it to take between two and three months to settle down. May it not be that this is the clinical picture of an epiphysiolysis of the acetabular cartilages, which is sometimes followed by acetabular deformity? If so, there is a fresh significance in this type of ' growing pain ', and, in its recognition, the opportunity to prevent the development of deformity, by insisting upon rest in bed, with or without weight extension, until epiphysial fusion has taken place.

TREATMENT

In the case of protrusions which have no joint complications, treatment may be required for two conditions: (1) Marked limitation of hip movement; and (2) The onset of secondary postural deformities.

1. Marked limitation of movement occurs in deep protrusions, and is due to bony contact between femoral neck and acetabular margin. It may be aggravated by the onset of joint irritability, which induces muscular spasm and precipitates the onset of secondary postural deformities. Operative treatment is necessary to remove bony contact, and this will be considered in the next section.

2. Secondary postural deformities develop more slowly in the lesser grades of protrusion. They are due to hip-flexion, forward pelvic tilt, and lumbar lordosis, and they attract attention because of alteration in posture and gait which they impose.

Non-operative treatment in the form of forcible stretching under anæsthesia, or weight-extension on an abduction frame, will usually suffice to overcome the

contractures round the hip. The capsule, the ilio-psoas, and the adductors will yield to one or other measure, when it will be found that these secondary deformities have been overcome and a useful range of movement recovered.

Osteo-arthritic Protrusions.—The majority of patients come for treatment with osteo-arthritic symptoms. One or both joints may be involved, and one is usually worse than the other. Occasionally one may have reached the stage of painless osteo-arthritic ankylosis. Each joint has therefore to be treated on its merits.

Two fundamental points should be remembered in planning treatment: (1) Severe degrees of protrusion have a great tendency to early osteo-arthritis and ultimate fixation; (2) Lesser grades degenerate more slowly, and painless movement may be retained for long periods with assistance.

In early osteo-arthritic cases palliative measures should always be tried first. These include the correction of postural deformity by rest in bed with weight-extension, the use of local heat in the form of diathermy, and re-education in active movements. A weight-relieving calliper will sometimes satisfy a patient whose joint aches at the end of a day's work. When such measures fail, and when the deformity is not too severe, operative treatment is called for.

In cases where the deformity is marked, and when the articular surfaces have become irregular, fixation to encourage ankylosis is the best course to follow, and for this the application of a plaster-of-Paris spica should suffice.

Operative Treatment.—Treatment by operation is indicated when: (1) Hip movement is limited by contact of femoral neck with acetabular margin; and when (2) Palliative measures fail to relieve moderate degrees of protrusion with painful osteo-arthritic changes.

The most attractive operation is the 'acetabuloplasty' devised by M. N. Smith-Peterson in 1936 for acetabular protrusion. The purpose of this procedure is twofold: (1) To remove bony contacts which prevent free motion in the hip and cause irritation within the joint; and (2) To remove a sufficiently large portion of the sensitive joint capsule, and so prevent painful impulses from reaching the sensorium.

This is accomplished by the resection of that portion of the acetabular margin which forms the anterior half of the roof and the anterior lip of the acetabulum, along with the attached segment of capsule which lies in front of the femoral neck. When these parts are ablated, the front of the neck and part of the femoral head are exposed, but, as they are supported by the ilio-psoas, adhesions do not develop to limit movement. The operation is conducted through muscle planes, and hæmorrhage is slight. The result is a minimum of shock and an early return to functional use in the joint. Cases leave hospital on the average at the end of three weeks.

By selecting these parts of the acetabular margin for removal, the new margin now lies to the medial side of the articular border of the head, and the plane of the acetabular orifice becomes oblique, as in the normal joint. The operation is suitable for both unilateral and bilateral cases with early osteo-arthritis, and if it fails as a palliative measure it has the advantage of not spoiling the field for a more radical procedure.

The writer has performed this operation once, and he is satisfied that it will increase the range of hip movement, but the event is still too recent to justify an appraisement of its merits.

In conclusion, my thanks are due to Dr. S. Whately Davidson for the care he took over the radiography of these cases; to Mr. James Brailsford for the illustrations he sent me; to Dr. Frank Stabler and Dr. Wm. Hunter, who confirmed certain pelvimetrical measurements; and to Professor Hey Groves for his kind suggestions in the preparation of this paper.

BIBLIOGRAPHY

POMERANZ, M. M., "Osteo-arthritic Protrusions of the Acetabulum", *Arch. of Surg.*, 1922, v, 691.
POMERANZ, M. M., "Intra-pelvic Protrusions of the Acetabulum (Otto Pelvis)", *Jour. Bone and Joint Surg.*, 1933, xiv, 663.
EPPINGER, H., "Pelvis Chrobak. Koxarthrolisthesis becken", *Beitr. d. Gehb. v. Gynäkol.*, 1903, ii, 176.
KIENBÖCK, "Uber die mit Protrusion des Pfannenbodens", etc., *Fortschritte*, 1912, xviii.
LOEBAL, R., "Zur Protrusion der Huftgelenkspfanne", *Ibid.*, 1917, xxxvi.
VALENTIN, B., and MULLER, HUGO, "Intra-pelvine Pfannenvorwolburg" (Pelvis Otto-Chrobak), *Arch. f. klin. Chir.*, 1921, cxvii, 3.
HERTZLER, "Osteoarthritic Protrusion of the Acetabulum", *Arch. of Surg.*, 1922, v, 691.
WALLER, J. B., "Ein 'Becken von Otto-Chrobak' mit Fractura Acetabuli", *Deuts. Zeits. f. klin. Chir.*, 1922, i–ii, 168.
DOUB, H. P., "Intra-pelvic Protrusion of the Acetabulum", *Radiology*, 1929, xii, 369.
KOHLER, ALBAN, *Rontgenology*, 1928, 193.
VERRALL, P. J., "An Unusual Bilateral Condition of the Acetabula—Arthrokatadysis", *Jour. Bone and Joint Surg.*, 1929, xi, Jan., 39.
FRÖLICH, M., "Migration intra-pelvienne progressive da la Tête femorale et Lésion de l'Ovaire", *Rev. d'Orthop.*, 1930, xvii, 553.
CARY and BERNARD, "'Arthrokatadysis' of the Hip", *Jour. Bone and Joint Surg.*, 1933, xiv, July, 163.
REED, E. N., "Arthrokatadysis of the Hip", *Ibid.*, 803.
GOLDING, F. C., "Protrusio Acetabuli", *Brit. Jour. Surg.*, 1934, xxii, July, 56.
BRAILSFORD, J. F., *Radiology of Bones and Joints*, 1934, 177, 186, 222.
SHAAP, C., "Intra-pelvic Protrusion of the Acetabulum", *Jour. Bone and Joint Surg.*, 1933, xvi, Oct., 811.
COHN, "Normal Bones and Joints", *Ann. of Roentgenol.*, iv, 1924.
PRYOR, "Differences in the Time of Development of the Male and Female Skeleton", *Anat. Record*, 1923, June, 257.
PARSONS and DAVIES, "Radiographic Study of Human Epiphyses", *Jour. of Anat.*, 1926, Nov., 484.
JOHNSTON, D. J. G., "The Strain of School-life on Girls during the Early Menstrual Period", *Brit. Med. Jour.*, 1935, ii, 892.
KEY, J. A., "Slipped Epiphysis of the Femur", *Jour. Bone and Joint Surg.*, 1926, xxiv, 95.
WILLIS, T. A., "The Slipping Femoral Epiphysis", *Ibid.*, 1929, Oct., 779.
PERKINS, G., "Treatment of Adolescent Coxa Vara", *Brit. Med. Jour.*, 1932, i, 55.
BERNSTEIN, M. A., and ARENS, R. A., "Epiphysiolysis", *Radiology*, 1927, ix, 597.
SMITH-PETERSON, M. N., "Acetabuloplasty", *Jour. Bone and Joint Surg.*, 1936, Oct., 869.

THE RELATIONSHIP OF ACETABULAR DEFORMITY TO SPONTANEOUS OSTEO-ARTHRITIS OF THE HIP-JOINT

AN INVESTIGATION OF THE INTRA-ARTICULAR FACTORS WHICH PREDISPOSE TO OSTEO-ARTHRITIC DEGENERATION

By JOHN GILMOUR

HONORARY SURGEON, ROYAL VICTORIA INFIRMARY, NEWCASTLE-ON-TYNE

In the foregoing paper on "Adolescent Deformities of the Acetabulum" the writer discussed the nature of protrusio acetabuli, and attempted to show that primary protrusions were to be recognized as the extreme degree of an acetabular deformity which was characterized by an increase in the depth of the bony socket. This condition was described as adolescent in origin, graded in severity, and related to premature epiphysial evolution.

The clinical records of a series of cases, personal and reported, established the fact that the presence of the deformity was detected by radiography in cases where attention had been drawn to the condition of the hip-joint on account of injury, limitation of some particular movement, the onset of static deformity affecting gait or body-posture, or the appearance of some complication in the joint. Clinical analysis showed that the commonest complication which forced patients to seek medical advice was osteo-arthritis. This affected over 80 per cent of protrusions, and appeared to develop spontaneously in one or both hips at any age, and on the slightest provocation.

The occurrence of spontaneous osteo-arthritis in one or both hips has for long been one of the major problems of surgery. The recognition of adolescent deformities of the acetabulum as a frequent cause of this condition is therefore of considerable importance, and a better understanding of the factors which predispose these deformities to osteo-arthritic degeneration should help towards a clearer conception of the problem. The purpose of this contribution is to examine those factors.

Whilst it is admitted that trauma, superimposed infection, or prolonged recumbency on account of some other disease, may precipitate arthritic changes in such joints, there is no doubt that these changes do occur in individuals who are apparently in good health, without the intervention of those factors. The one factor which emerges from an examination of numerous radiographs of the deformity is the influence of the depth of the acetabulum itself. Indeed, it appears to be a rule of the condition that "the deeper the socket, the greater is the proclivity towards osteo-arthritic degeneration". This suggests a mechanical cause, but it must be different from that which obtains in all the other deformities of the hip-joint, for in them the incongruity of the articular surfaces is usually regarded as the exciting factor, whereas in protrusions and in deep acetabula the congruity of the articulating surfaces is usually very well preserved. The problem, therefore, is to consider how an increase in acetabular depth can operate to the detriment of the normal hip-joint mechanism.

The Normal Mechanism of the Hip-joint.—Walmsley[1] has shown that there is a movement of the femoral head from the socket in flexion, and a screw-home movement into the socket in extension, which is complete when the femur is

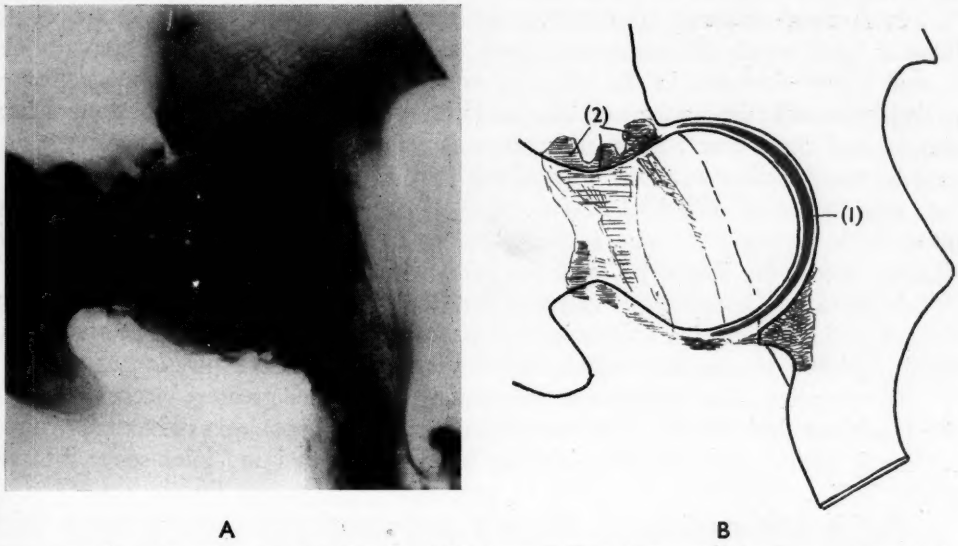


FIG. 475.—Preparation of a hip-joint in which the synovial fluid is replaced by 20 c.c. of iodized sperm oil. A, Radiograph of the joint in *full flexion*. Note: (1) The crescentic layer of fluid in the acetabular cavity; and (2) The rest of the fluid lying beneath the folds of the capsule towards the outer part of the femoral neck. B, Key diagram.

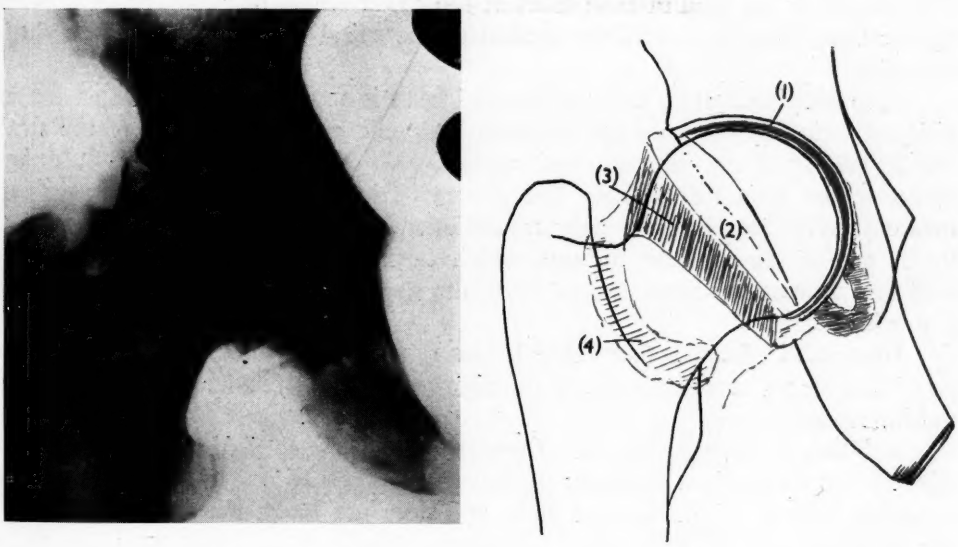


FIG. 476.—A, Radiograph of the joint in *full extension*. Note: (1) The thinner crescentic layer of fluid in the acetabular cavity; (2) The 'clear' band which occurs in the region of the cotyloid ring; (3) The collar of fluid which surrounds the outer part of the femoral head and adjacent part of the femoral neck; (4) The residue of fluid which lies in the outer part of the joint. B, Key diagram.

hyper-extended by 10°. He held that there is a slight difference in the diameter of the femoral head in two planes, which permits bony locking to end the movement of extension.

The screw-home movement in extension can be verified by watching it through a trephine hole in the acetabular fossa. It is brought about by the spiral fibres of the capsule, which first wrap themselves round the femoral neck, and then impel the head into the socket during extension.

It is more difficult to demonstrate the inequality in the curvature of the femoral head which Walmsley described, and it is doubtful whether the hip-joint is ever hyper-extended in the ordinary erect position. Some other mechanism is probably brought into action within the joint, when its components become a fixed couple, and the writer believes that there is a fluid-mechanism which plays a vital part in the function and economy of the joint.

The Protective Fluid-mechanism of the Hip-joint.—This mechanism depends upon three factors: (1) The sucker-like grip of the cotyloid ring cartilage on the femoral head. (2) The capsule of the joint. (3) The synovial fluid.

In flexion, the capsule is relaxed, the femoral head loses its firm contact with the cotyloid ring, and the acetabular and subcapsular parts of the joint communicate freely, synovial tension is lowered, and the joint passes into a position of ease.

In extension, the screw-home movement brings the greatest circumference of the head into firm contact with the cotyloid ring, the capsule is tightened, synovial tension is raised, and the cotyloid ring divides the remaining joint-space into two parts.

Radiographic studies of a hip-joint preparation, with iodized sperm oil in place of synovia (*Figs.* 475, 476), show that in extension there is a crescentic layer of fluid within the acetabulum, separating the joint surfaces, and a subcapsular collection surrounding the margin of the femoral head and supporting it externally. The tension of the fluid in both sides of the 'ring' must be equal, being produced by the same force—namely, the tension of the spiral fibres of the capsule during extension.

It follows, therefore, that the femoral head is supported during extension and weight-bearing by an inner and an outer hydraulic buffer, responsive to the strains which fall upon the capsule, and mutually supporting. The inner fluid layer separates the articular surfaces and prevents frictional contact, serving also as a medium under tension for weight transmission. The outer cushion maintains the inner, and is the medium through which capsular strains set up a fluid tension sufficient to balance these, and to distribute their effects. It behaves, in fact, like a shock absorber.

Increased Acetabular Depth and the Joint-mechanism.—Increased acetabular depth modifies each of the above-mentioned factors responsible for the fluid-mechanism :—

1. There is a *progressive loss of contact between the cotyloid ring and the femoral head* as the acetabulum deepens, until, in deep protrusions, the ring encircles the irregular contour of the femoral neck, and does not touch the articular surface of the head.

a. When deepening is slight the articular margin of the head may pass within the ring at the extremes of movement.

b. When the socket protrudes, and the whole head lies within the ring, every movement of the head will cause a loss of contact at some point or points.

c. In extreme protrusions, there will never be any contact between the ring and the head.

It follows, therefore, that there must be a progressive failure in the function of the cotyloid ring as the socket deepens, and that the effect will be to diminish the efficiency of the fluid buffer within the bony part of the joint in like proportion.

The element of frictional contact between the articular surfaces will therefore appear as an increasing factor in the economy of the joint, leading to the impairment of its smooth functioning, and ultimately to degenerative changes in the articular cartilages and the underlying bone.

2. *Capsular changes.* As the socket deepens and the head sinks within it, the base of the femoral neck approaches the acetabular margin. The capsule of the joint adapts itself to this change and is 'taken up' in consequence. When the pelvis is tilted forward on the hip, there is further shortening in the capsule, and a degree of fixed flexion is commonly found.

It follows that *capsular shortening is a feature of acetabular protrusions*, which increases with the degree of the deformity. This must modify the joint-mechanism considerably :—

a. It prevents the free separation of the articular surfaces in further flexion, and maintains them in closer apposition than normally obtains.

b. It diminishes the range of capsular torsion and so reduces the force normally used to create an efficient fluid cushion within the articulation.

c. It must have a detrimental effect on the amount of active synovial membrane within the joint, for constant pressure on the intra-acetabular membrane will lead to its atrophy, and capsular shortening may well be accompanied by a diminution of the synovia lining the capsule.

3. Thus there is probably also a *reduction in the supply of synovial fluid* necessary for the proper function of the joint.

It appears, therefore, that with increased acetabular depth there is brought into being a set of mechanical factors which impair the economy of the hip-joint in direct proportion to the grade of the deformity. This will explain why degenerative changes have been found in such hips in every decade from the second to the sixth, and why this type of joint is so susceptible to superimposed infection and to trauma.

The actual development of osteo-arthritic changes appears to be directly related to the impairment of function, which is due to the deformity itself :—

a. When function is fairly well preserved, changes develop slowly. X-ray examination shows that these consist of :

i. Thinning of the joint-space, i.e., of the articular cartilages.
ii. Eburnation of the acetabular cortex in the course of years.
iii. The slow formation of marginal osteophytes on the head and acetabulum.

b. Where there is greater interference with the joint mechanism, destructive changes occur earlier, and the radiographic findings show :

i. Thinning of the joint space.
ii. Local thinning at the 'point of pressure' (loss of fluid buffer).
iii. Marginal osteophytes.
iv. Ossification of the transverse acetabular ligament and cotyloid labrum.
v. Osteosclerosis of subarticular bone with cystic spaces.
vi. Deposition of subperiosteal bone on the inner pelvic wall.

c. Trauma, superimposed infection, and progressive degeneration lead to osteo-arthritic ankylosis. Radiography shows that in such cases :

i. The joint line becomes thin and angular as the surfaces collapse.

ii. Peri-articular sclerosis is greater.

iii. Osteophytes interlock between the head and acetabulum.

iv. A further degree of protrusion may develop from collapse of the acetabular floor, leaving a gap between the head and the original curve of the acetabular roof.

SUMMARY

1. The onset of spontaneous osteo-arthritis in the hip-joint is common when the acetabulum is increased in depth.

2. In the normal hip-joint there is a protective fluid mechanism which plays an important part in weight transmission and in joint economy.

3. This mechanism depends upon the free operation of intra-articular factors. These are discussed in detail.

4. In acetabular deformities there is a loss of function and an interference with the operation of the fluid mechanism which is proportional to the increase in acetabular depth.

5. Osteo-arthritic degeneration develops whenever this fluid mechanism is impaired, and is accelerated by trauma, superadded infection, and any remote cause which lowers the vitality of the individual.

REFERENCE

[1] WALMSLEY, T., "The Articular Mechanism of the Diarthroses", *Jour. Bone and Joint Surg.*, 1938, xi, Jan., 40–45.

OSTEITIS FIBROSA DISSEMINATA
REPORT OF A CASE

By MARK COLEMAN
ASSISTANT IN THE SURGICAL UNIT, UNIVERSITY COLLEGE HOSPITAL

INTRODUCTION

THIS case is reported since it is believed that it belongs to a group characterized by a syndrome not yet fully recognized. The syndrome consists of: (1) A disseminated osteitis fibrosa; (2) Areas of cutaneous pigmentation which have a distribution suggesting some connection with the bone lesions; and (3) Sexual and somatic precocity in females, but apparently not in males.

Fuller Albright[1] and his co-worker have described 7 cases in detail, and have also reviewed 13 cases from the literature, of which 9 were found to be strikingly similar, and 5 suggestively similar, to the fully developed syndrome. They state that " If pathological manifestations, which at first seem to be totally disconnected, are found to occur together in a sufficient series of patients some relation between them is apparent ". The case here described possessed several features common to dyschondroplasia (Ollier's disease), but obviously could not be grouped with that disease; whilst interference with growth made one hesitant to accept it as a case of multiple focal osteitis fibrosa with associated pathological curiosities. I have not been able to discover a similar case from the British literature, and it remained a bizarre pathological entity until I became acquainted with the syndrome at the Massachusetts General Hospital, Boston. The syndrome derives its importance from its resemblance to hyperparathyroidism associated with bone lesions, since 6 of the reported cases were submitted to a fruitless exploration of the neck in search of enlargements of the parathyroid glands.

CASE REPORT

HISTORY.—Healthy male, white, aged 13 years. This patient was first admitted to University College Hospital in February, 1935, with the history of recurrent fractures of bones due to accidents associated with trivial violence. The first fracture occurred in 1934, when he was admitted to another hospital giving a history that while he was leaning against a drain-pipe he was pushed and heard a crack in his right arm. The right humerus was found to be fractured at the site of a localized cystic region in the proximal half of the shaft. Further radiographs showed involvement by similar disease of both femora and the right tibia, and ill-defined changes in the left humerus. At operation the cysts in the humerus were explored and curetted. Healing occurred uneventfully and the diagnosis was made of pathological fracture due to fibrocystic disease.

Later in the same year, whilst walking downhill, he slipped and sustained a second pathological fracture through a cystic area in the left femur. With conservative treatment the fracture healed in average time and he was transferred to our care for investigation.

He was born in London, of healthy parents and grandparents. The youngest member of four children, there was no history of bone disease in his brothers or sister, nor in any other more distant member of the family. Apart from scarlet fever at the age of 6 years there appeared no other relevant medical history.

ON EXAMINATION.—A poorly grown lad for his age, moderately well nourished, with a pale pasty complexion. The blood-pressure, temperature, and pulse were normal. At first he appeared of average intelligence, but during the ensuing eighteen months his mental outlook remained childish and definitely dull, and without usual vivacity. No pubic hair was ever noticed; the penis was normal size, but the testes were small. (*Figs.* 477, 478.)

The facies was dull and expressionless; there was obvious asymmetry of the face, the left side being less developed than the right. The left palpebral fissure was smaller than the right, but the pupils were equal in size.

There was no abnormality in the central nervous system, heart, lungs, or abdomen.

The teeth were healthy; the neck normal to palpation. (There is no record of obvious pigmentation of the skin, but no diligent search was ever made.)

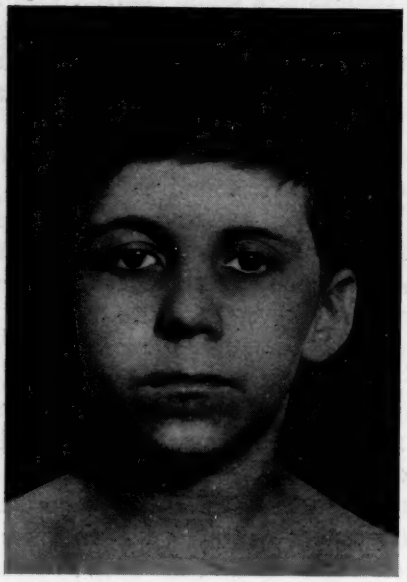


FIG. 477.—Showing the facial asymmetry and narrowed left palpebral fissure.

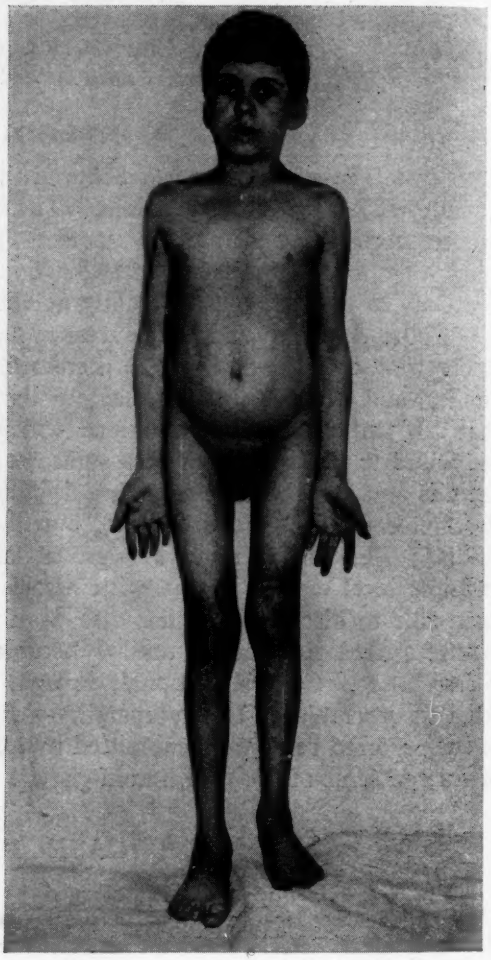


FIG. 478.—Showing the difference in growth of the lower limbs.

The upper limbs were of equal length, with normal arm and shoulder musculature. Extending from the right anterior axillary fold down the front of the arm was a healed linear scar some four inches long. The underlying bone felt normal.

When standing, the pelvis was lowered on the left side, the spine showing a lumbar scoliosis, with compensatory curves in the dorsal region. The left leg showed 6 cm. of true shortening, of which 2·5 cm. were accounted for in the tibia and the remainder assigned to the shaft of the femur (Nélaton's line and Bryant's triangle showed no deviation from normal). There was no muscular wasting of the affected limb, but circumferential measurements of the thigh and calf were less than in the opposite limb. The skin was normal in colour, texture, and heat, and the arteries around the ankle and in the groin were easily palpable.

The lower two inches of the left femoral shaft just above the condyles showed irregular thickening, bony in consistence and not tender.

The joints all functioned normally.

Blood-chemistry.—

Serum calcium: 9·6, 10·3, 10·9, 10·3, 10·2, 11·8 mg. per cent at different estimations over 23 months.

Plasma phosphorus: 3·2, 4·4, and 5·2 mg. per cent estimated over a period of 23 months.

Serum phosphatase: 4, 4·5, and 4 units.

Blood-cholesterol: 180 mg. per cent.

Blood-count: 4,693,000 red cells per c.mm., hæmoglobin 84 per cent, colour index 0·91; 6400 white cells per c.mm., differential count normal.

Urine.—No Bence-Jones proteose present. Urea-concentration test and blood-urea within normal limits.

X-ray Examination.—Radiographs showed multiple localized lesions with normal bones elsewhere. These consisted of cyst-like areas (indistinguishable from osteitis fibrosa cystica) at the lower ends of the shafts of the femora and the upper end of the right tibia. At the opposite ends of these named bones were smaller lesions in the region of the lesser trochanter and at the distal end of the tibial diaphysis. The middle of the shafts of the humeri were involved and there was also a single cyst of the right pubic bone. The cysts, clean-cut and well-defined, involved both medulla and cortex, in some regions expanding the shaft and everywhere entirely replacing the normal architecture of the bone. There were also areas of increased density either associated with the cysts or as irregular speckling, particularly at the lower ends of each humerus.

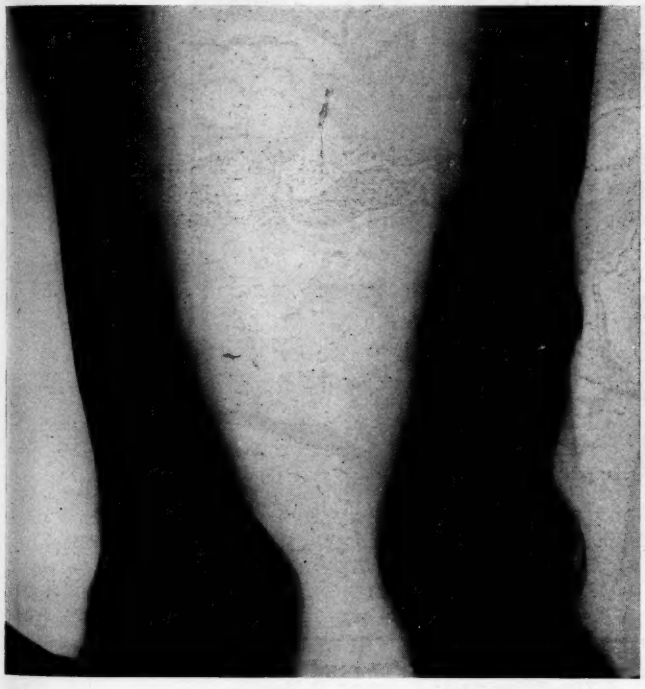


FIG. 479.—Note the cystic changes in the lower ends of the femora. A fibular transplant has been inserted on account of a pathological fracture in the left femur. Note also the normal density of the bones apart from the lesions.

FIG. 480.—Showing cystic disease in diaphysis of humerus, with ends of bone apparently normal. Note the condensed bone around the cysts.

In the upper end of the left ulna, and in other bones to a less marked degree, were vertical striations more marked than rather similar striations often associated with disuse atrophy.

In each case the epiphyses of the affected bones escaped, and, with the exception of a small cyst in the right pubic bone, no lesions were seen in the pelvis, vertebræ, ribs, scapulæ, clavicles, or skull. (*Figs.* 479, 480.)

CLINICAL COURSE.—On April 8, 1935, the lesions at the upper and lower ends of the right tibia were explored and portions of bone removed for biopsy. The cortical bone was found to be very hard, whilst the cysts contained greenish-brown fluid. Microscopically the bone removed showed characteristic changes of osteitis fibrosa.

On December 9, 1935, in order to strengthen the lower end of the left femur, which had re-fractured, a free fibular graft was transplanted and the limb immobilized in plaster.

FIG. 481.—Drawing showing the aneurysm at the commencement of the thoracic aorta. A, Aneurysm of aortic arch; B, Descending aorta; C, Lung; D, Heart.

On November 4, 1936, he complained of a sudden attack of severe abdominal pain commencing on the right side and passing across the middle. A mass was palpable beneath the left rectus in the line of the transverse colon and he became white and pulseless. Immediate laparotomy revealed acute hæmorrhagic pancreatitis, and he died shortly afterwards.

It is interesting to record our experiences of *radiotherapy* in this case:—

1. Interstitial irradiation to lesion at lower end of left femur. Dosage: 3696 mg.-hr.
2. Irradiation by 1-g. unit to lesion at lower end of right femur. Dosage: 24 g.-hr.
3. X-ray therapy to lesion in middle of shaft of humerus. Kilovoltage, 190. Thoreas filter equivalent to 1·5 mm. copper. Milliamperage, 7. Anti-cathode skin distance, 30 cm. Portal of entry, 10 cm. × 15 cm. Dosage: 1250 r, spread over five days.

The course of X-ray therapy was repeated twice, at intervals of three and four months. No change was seen in either of the lesions treated by interstitial irradiation, or in the lesion treated by the 1-g. unit. Calcification in the cystic areas was first noticed in the lesion treated by X rays ten months after the first course of irradiation, and it increased until death occurred.

AT AUTOPSY.—Only the abnormal findings are recorded.

Heart.—About 2 oz. of clear pericardial fluid. A little epicardial fat. Heart not obviously enlarged; myocardium normal, though pale; endocardium and valves quite normal. Aorta —no atheroma throughout, wall well formed. Immediately beyond the arch there was partial coarctation, the lumen being narrowed to nearly a third of normal width. No ductus arteriosus. A saccular aneurysm, about 4 cm. in diameter, projected posteriorly and inferiorly from the commencement of the thoracic aorta. It showed a well-formed smooth wall identical with that of the aorta, with no clot. Into its sac opened two or three small collateral vessels. Between the aneurysm and stenosis was a mass of fibrous tissue and clot, attached to the wall of the aorta, resembling thrombus. Veins normal. No thrombosis or dilatation found. (*Fig.* 481.)

Pancreas.—Enclosed in a large hæmatoma which tracked into retroperitoneal tissue, mesentery, and greater and lesser omenta. Most of the clot was very firm and black, with

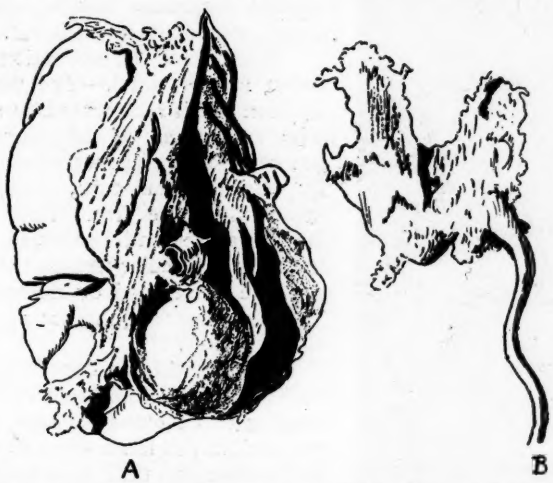


FIG. 482.—Drawings from photographs showing: A, The hypertrophied right kidney; and B, The faulty development of the left kidney.

a distinct layer of fibrin posteriorly. Central softening with cyst formation was commencing in the mesentery. Part of the pancreas appeared completely disorganized from necrosis; other portions were quite enclosed in blood-clot, yet appeared healthy. Numerous small areas of fat necrosis. Pancreatic duct not dilated. Pancreatic arteries could not be found, but the veins were free from thrombosis.

Kidneys.—Right kidney difficult to find and consisting of a tiny body about 3 cm. by 2 cm., with uniform atrophy of renal substance. Small pelvis and normally formed ureter. Left kidney very large and pale. Capsule stripped easily and cleanly, disclosing a smooth surface. Near the hilus were several irregular yellow masses (1 to 2 cm. in length) extending to the surface. These were soft, ill-defined, not vascular, and resembling lipoid masses—somewhat like cortical substance of the suprarenals. Corticomedullary pattern normal, cortex broad, substance firm but not tough. Pelvic fat not increased. Vessels not prominent or thickened. (*Fig.* 482.)

Genitalia.—Bladder and prostate normal. Testes small, but normal. Epididymes rather large, vascular, but normal. Vas of seminal vesicles normal.

Ductless Glands.—Pituitary of average size, soft, grey, looked normal. Adrenals—right smaller than left, both showed much lipoid in cortex. Thyroid, average size, appeared quite normal. Parathyroids, no obvious enlargement. (An exhaustive search was made of the structures of the neck, substance of thyroid and thymus glands, and superior mediastinum, but not a single parathyroid gland was found.—M. C.)

Alimentary Canal.—Hæmatoma tracking along ascending and descending colon, where it had burst through into peritoneal cavity. Huge blood-clots at both flexures, about 20 oz. of fluid blood in peritoneal cavity. Mesenteric glands not enlarged.

Brain.—Very pale, soft. Practically no cerebrospinal fluid in ventricles. No obvious abnormality in brain substance, membranes, or blood-vessels. Middle ear and nasal sinuses clear.

Bones.—Ribs showed much red marrow, but no obvious abnormality of bone. Vertebræ appeared normal. Calvarium normal. Right humerus, left femur, tibia, and fibula removed for examination. Left femur showed marked anterior bowing in lower third at site of fracture. Bone-graft firmly attached to bone tissue. Immediately beneath it a large gelatinous cyst with much fibrous tissue. Cortex of bone firm. Spongiosa very rarefied. Bone very soft at epiphyses. No red tumours found. Humerus showed great softening, very fibrous tissue in shaft, greyish marrow, much rarefaction of corticalis and spongiosa. Fibula showed extremely narrow shaft, barely 5 mm. across, extremely soft, fibrous. (*Fig.* 483.)

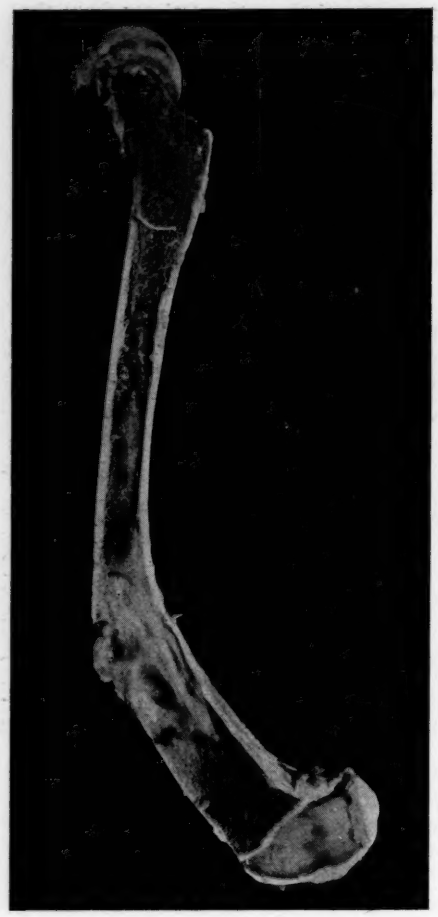


FIG. 483.—Photograph of lesions in femur. Note the diffuse segmental fibrosis enclosing multiple cysts.

HISTOLOGY (Examination of tissue from lesion in left tibia).—The periosteum shows no reaction and is represented by a thin fibrous sheet. The architecture of the cortical bone and medulla has completely disappeared and has been replaced by irregular trabeculæ, many fused, but others apparently quite free. They surround enlarged lacunar spaces and Haversian systems which are filled by a vascular fibrous tissue. The trabeculæ are here often lined by numerous osteoblasts, but there is a marked absence of osteoclasts in Howship's lacunæ.

Deeper still is a dense layer of fibrous tissue, well-formed fusiform cells with prominent nuclei tending to be closely applied to the bone. Near the medulla this tissue tends to become structureless and collagenous until it is limited by the wall of a cyst. Within this fibrous region are numerous areas of metaplasia, as evidenced by calcareous structureless masses surrounded by osteoblasts and containing embedded cells. Numerous small cysts are also present, arising in regions where the fibrous tissue is healthy or apparently degenerating. Some of these are lined by flattened cells; others have no lining.

Adjacent to the trabeculæ are several foci of chronic inflammatory cells, lymphocytes, plasma cells, red blood-cells, and multinucleated cells loaded with pigment. No fat cells are recognizable.

The trabeculæ everywhere tend to present a more or less uniform picture, consisting of a central region of structureless matrix enclosing a few individual cells (tending to stain blue with hæmatoxylin) surrounded by a peripheral region of coarsely striped bone. These markings run for the most part parallel to the length of the trabeculæ. Thin zones of osteoid tissue are irregularly applied on to the surface of some trabeculæ.

No lamellated bone can be definitely distinguished. At the edge of a lesion a single trabecula would appear to be sufficient demarcation between normal marrow cells on the one side and a dense fibrous tissue on the other. The aspect of the trabecula facing the fibrous tissue is irregular and covered with osteoid tissue, whilst that towards the marrow has a normal appearance. No osteoclastic deposits are present.

There is no evidence of active destruction of bone, but rather general signs of a healing phase.

DISCUSSION

So far the case here described does not fully conform with the tenets of the syndrome as enumerated in the introduction, but amplification brings more justification.

Albright[2] stresses the cutaneous pigmentation as one of the cardinal features of the disease. "It is patchy and the individual patches tend to remain on either one side or the other of the midline. They occur most frequently over the sacrum, buttocks, and upper spine." In this case no pigmentation was recorded, since its importance was not realized. Had it been great in amount its presence would hardly have been missed. On the other hand, in one of the recorded cases the scalp had to be shaved in order to demonstrate the presence of the pigmentation. *Fig.* 484 demonstrates a marked example of the pigmentation, and it recalls a similarity with the cutaneous lesions of neurofibromatosis. It is interesting to record that the latter disease may also be complicated by bone lesions producing either: (*a*) Scoliosis of the spine; (*b*) Irregularity of outline of the shafts of long bones, including changes which in the X-ray picture appear as subperiosteal bone cysts; or (*c*) Abnormalities of growth. These changes have been explained on the basis of the reaction by the periosteum or metaphysis to the presence of nervous tissue affected by the fibrous changes characteristic of von Recklinghausen's disease.[6] Gould[7] has studied the histology of these cases and emphasized that von Recklinghausen's neurofibromatosis affects bone as well as skin and nerve; he stated that the bone changes are similar to those of osteomalacia in the presence and arrangement of osteoid tissue.

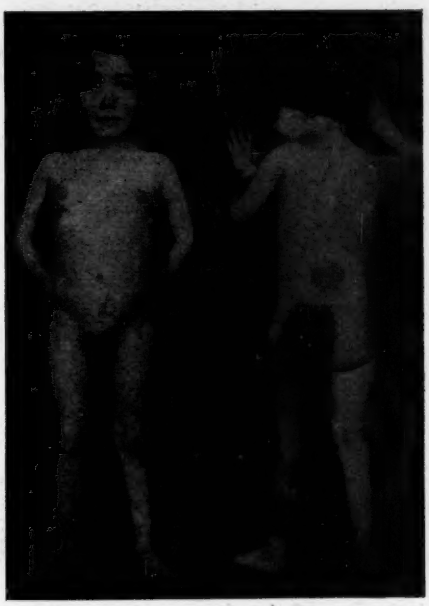


FIG. 484.—Photograph of child, aged 3¾ years. Note extension of pigment down leg and secondary sex development. (*From the 'New England Journal of Medicine', by courtesy of Dr. Fuller Albright.*)

The syndrome appears in its classical form in females, who show an endocrine dysfunction with precocious puberty. In males the onset of puberty appears not abnormal, and in fact there is less marked, if any, precocity. In one of the recorded cases the testes were small, whilst the secondary sex characteristics were normal. This corresponds with the case here described. In females there tends to be early union of the epiphyses. In several of the recorded cases growth was retarded, in one however the affected bones showed lengthening. It may well be that some such explanation might account for the asymmetry of the face and lower limbs in this case, although it must be admitted that examination of the radiographs reveals apparently normal epiphyses in the affected long bones. On the other hand, such selective interference with growth suggests a local abnormality, congenital or acquired, rather than a diffuse hormonal affection.

Confirmative evidence rests on a case shown to me personally at the Massachusetts General Hospital—almost an exact replica of the case here described.

The patient was aged 21 years and was mentally a little dull, although sufficiently intelligent to work at making surgical braces. He had asymmetry of the face, multifocal osteitis fibrosa, cutaneous pigmentation over the nape of the neck and occipital regions of the scalp, and he was raising the sole and heel of one shoe since he discovered that he could thus overcome a limp.

Hunter and Wiles[3] record that in six cases of unilateral dyschondroplasia there was marked facial asymmetry, and they reported in 1935 a further case showing 2 in. of shortening of the right lower limb, but without facial asymmetry. Although the lesions in the case here reported were mainly unilateral and facial and lower limb asymmetry were present, the lesions in the upper limbs lay in the mid-region of the shafts, the epiphyses were not involved, and biopsy showed no trace of cartilage and a classical appearance of healing osteitis fibrosa. This would tend to show that asymmetrical growth of limbs or face might be misleading as a diagnostic sign, the only common features of the two groups of cases being multiple lesions causing softening and bending of bones, associated with abnormal growth.

It is probable that in its complete form the disease is quite uncommon. However, it is not unreasonable to assume that the disease may be present even if only one or two of the triad of symptoms are exhibited. Apparently single focal lesions of osteitis fibrosa, or conditions described in the literature under the titles of osteodystrophia fibrosa unilateralis[4] or non-generalized fibrous osteodystrophy,[5] might belong to this syndrome.

The disease appears to be quite distinct from hyperparathyroidism, in which the biochemical findings of disturbed calcium metabolism and diminished density of shadows of the whole skeleton are characteristic. But it is now recognized that identical biochemical findings may be present in hyperparathyroidism where the bones appear normal to X rays but calculi are present in the kidneys. In these latter cases there may be the classical adenoma of one or more parathyroids or hyperplasia of all the parathyroid glands. We do not know the stimulus which is responsible for the increase in size or tumefaction of the parathyroids with coincident increase of parathormone in the circulation. It has been proved that the increase of parathormone eventually causes a depletion of skeletal calcium, but we are ignorant of the factors responsible for the fibrous changes that occur in the bones. It may be that the primary aetiological cause is found neither in the parathyroid gland nor in the bone; possibly in a lesion in the central or peripheral nervous system. It is at this point that hyperthyroidism may have common ground with the syndrome here described.

Bentzon, quoted by Freund,[4] experimented in young rabbits by injecting absolute alcohol in an attempt to influence the sympathetic cord. In one rabbit temporary but gross changes were observed in bones of the forepaw, which were interpreted by Freund[4] as very similar to that found in fibrous osteodystrophy. He assumed that the bone changes were secondary to disorders of the innervation of the blood-vessels. One conclusion suggested by these experiments is that a disordered vegetative nervous system might be responsible for the fibrous lesions in the bones.

It is suggested that the endocrine disturbance, the bone lesions, and the pigment spots may be manifestations of an underlying neurological disturbance or of an embryological defect. In one of Albright's reported cases[2] the right abdominal and cremasteric reflexes were absent, whilst those on the left were normal. In addition

there was diminished sensation to pin-prick on the right, over the area supplied by the fourth dorsal to the first lumbar nerves. Some cases showed definitely retarded mental development. The experiments of Freund cited above might be adduced as additional evidence, as also the fact that von Recklinghausen's neurofibromatosis shows skin pigmentation, nerve lesions, occasionally facial or spinal asymmetry, and cysts in long bones.

Finally, the differentiation from hyperthyroidism rests on the normal calcium metabolism, the characteristic X-ray lesions of disseminated focal osteitis fibrosa with intervening normal bone, the presence of cutaneous pigmentation, and the sexual and somatic precocity when the disease occurs in females.

CONCLUSIONS

A case of multifocal osteitis fibrosa is reported which it is claimed should be grouped in a syndrome characterized by: (1) Multiple bone cysts; (2) Areas of pigmentation; (3) Precocious puberty in females, but apparently not in males.

Attention is drawn to the importance of differentiation from hyperparathyroidism to avoid a useless operation.

It is suggested that these varying manifestations might be ascribed to an underlying neurological disturbance or to an embryological defect. Certain features of Ollier's dyschondroplasia, hyperparathyroidism, focal osteitis fibrosa, and neurofibromatosis are correlated with the present syndrome.

I am indebted to Dr. Fuller Albright and Professor Edward Churchill, of Boston, for instruction and kind permission to refer to their work. From the writings of the former I have quoted fully.

I am also indebted to Mr. E. K. Martin, under whose care the case was admitted, for permission to publish it; to Professor R. G. Cameron for the post-mortem findings; and to Dr. Gwen Hilton for the radiotherapeutic details.

REFERENCES

[1] ALBRIGHT, F., *New Eng. Jour. Med.*, 1937, ccxvi, April.
[2] ALBRIGHT, SCORVILLE, and SULKOVITCH, *Endocrinology*, 1938, xxii, April.
[3] HUNTER, D., and WILES, *Brit. Jour. Surg.*, 1934–35, xxii.
[4] FREUND, E., *Arch. of Surg.*, 1934, xxviii, 849.
[5] FREUND, E., and MEFFERT, *Surg. Gynecol. ond Obst.*, 1936, lxii.
[6] BROOKS and LEHMAN, *Ibid.*, 1924, xxxviii.
[7] GOULD, A. E., *Quart. Jour. Med.*, 1918, April.

COMPLETE THYROGLOSSAL FISTULÆ

By VICTOR J. KINSELLA, Sydney

At the end of the nineteenth century and the beginning of the twentieth, it was the accepted practice to incise thyroglossal cysts and fistulæ and then make an attempt to destroy the lining membrane from within, by cautery or by caustics. Recurrence was common after this procedure, so attempts were made to remove the tract by dissection. But dissection is difficult in the suprahyoid region, because here the tract is friable and hard to define. Sistrunk, in 1920, described his method of removing a part of the hyoid bone and a cylinder of tongue substance a quarter

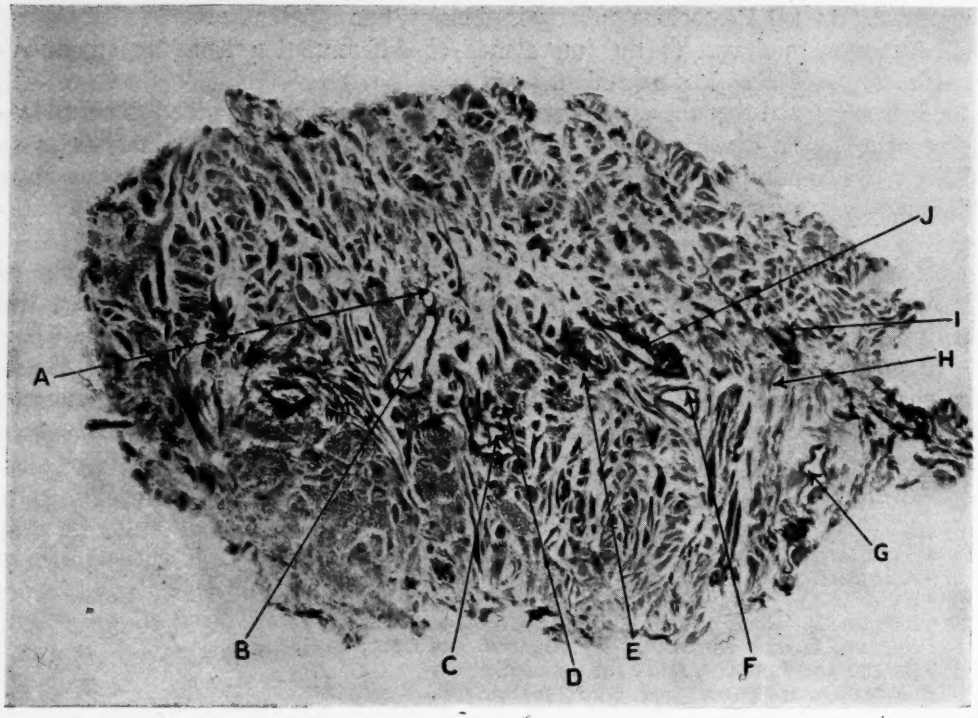


Fig. 485.—Low-power view of transverse sect on of cylinder of tongue in a baby, aged 4 years, showing the thyroglossal tract cut across ten times.

of an inch in diameter, no attempt being made actually to define the upper part of the tract, and this procedure became the accepted routine. But cases of recurrence are still found, even after repeated operations by skilled surgeons. A study of the records in the three teaching hospitals of Sydney, revealed the histories of 98 patients operated on for thyroglossal cysts and fistulæ. Of these, 37 had records of previous operations (chiefly excision), varying in number from one to four. It is possible that in some others, previous operations have not been recorded. Crotti states in the recent edition of his book, that 11 of his 19 cases had had previous operations, varying

in number from one to four. In some cases of recurrence the operation wound fails to heal, but in most, recurrence occurs some months after operation. The difficulty lies above the hyoid bone. In this part, there is no guide for the surgeon in the bleeding mass of tongue substance. Sistrunk advised following an imaginary line bisecting the right angle between lines perpendicular and horizontal to the body of the hyoid. But it is geometrically impossible to erect perpendiculars and horizontals to irregular bodies such as the hyoid bone. Moreover, even if the surgeon could find and follow such a line, it is by no means certain that the thyroglossal tract would correspond with it.

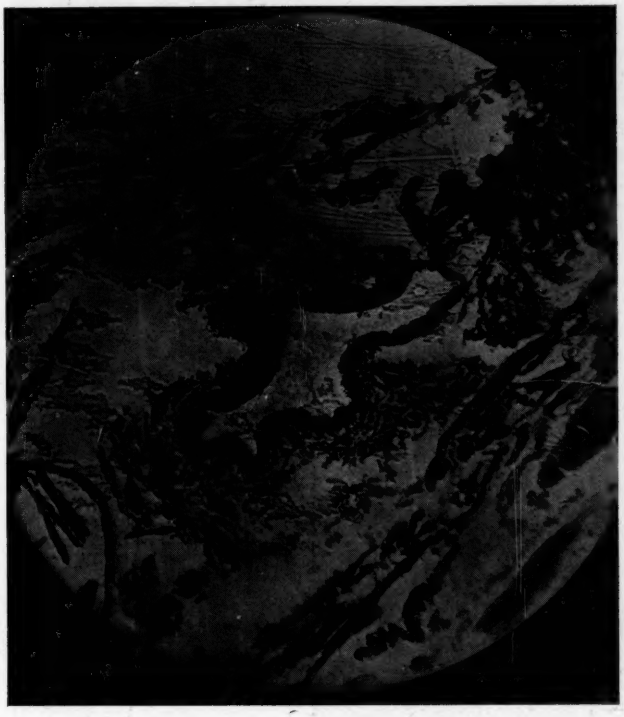


FIG. 486.—High-power view of part of *Fig.* 485, showing irregular shape of tract and thinness of walls.

The first case which helped me to understand the tendency to recurrence was that of a baby, N——, aged 4 years, whose fistula I removed by Sistrunk's method five years ago. *Fig.* 485 shows a low-power view of a transverse section of the cylinder of removed tissue in its lingual part. In this one section the tract is seen to be cut across ten times. This must mean that the tract is very tortuous or has numerous diverticula. *Fig.* 486 shows a high-power view; the tract is seen to be of irregular shape and of microscopic calibre, with walls no more substantial than a layer of epithelium. It appears that if the whole tract is to be successfully removed in such a case by coring a narrow cylinder of tissue through the tongue, one must be aided by good fortune. If, on the other hand, parts of the tract are left behind, isolated in the tongue substance, they may cause recurrence.

The suggestion naturally presents itself that perhaps these fistulæ could be managed by effecting a firm closure of their skin end, trusting to the pharyngeal

opening to carry away their secretions. A study of the literature did not encourage this line of action. Crile[1] stated that no complete fistula with outer skin orifice or inner pharyngeal opening has ever been reported. Semken[2] made a similar statement.

Nevertheless this method has been carried out in 2 personal cases, details of which are given below.

CASE REPORTS

Case 1.—In January, 1935, a patient, W. M., aged 21 years, presented himself with a thyroglossal fistula. He had had a discharging point on the front of his neck for as long as he could remember.

On Examination.—The skin opening of the fistula was near the upper border of the thyroid cartilage and slightly to the right of the middle line. The isthmus of the thyroid gland could be felt in its normal position. The fistulous tract was easily palpable as it passed upwards, and could be made to roll under the finger on the anterior aspect of the body of the hyoid bone to the right of the middle line.

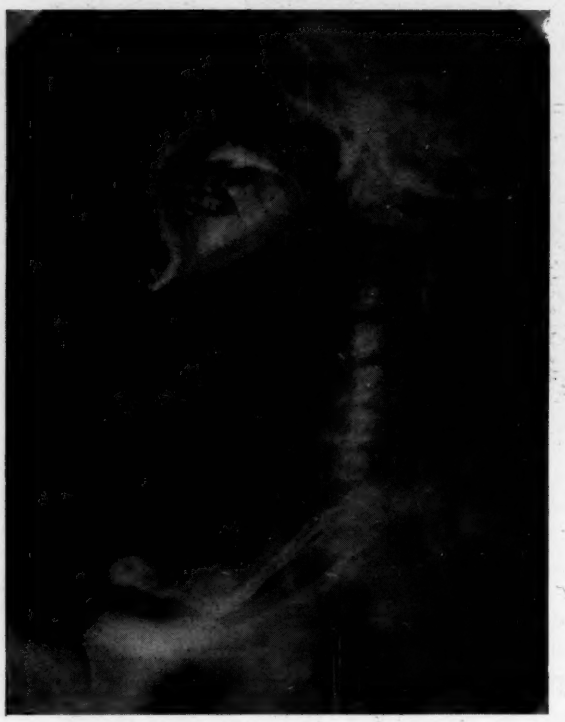


Fig. 487.—*Case* 1. Radiograph of tract.

X-ray Examination.—The patient was sent for X-ray examination of the tract, after injection of iodized oil. Almost as soon as the oil was injected at the skin opening, the patient stated that he could "taste the stuff" in the back of his mouth. A little more was injected and the radiograph taken (*Figs.* 487, 488). This shows a tract of simple tubular type, leading upwards to a patent foramen cæcum. It passes anterior to the body of the hyoid bone, and a little higher up a posterior convexity marks the anterior belly of the digastric. The posterior line of iodized oil is in the pharynx.

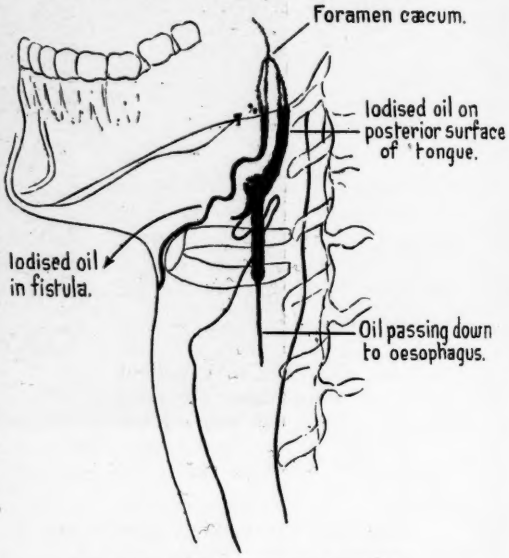


Fig. 488.—Key diagram to *Fig.* 487.

At Operation.—On February 7, 1935, at St. Vincent's Hospital. A transverse incision was made in a skin crease just below the fistulous opening and a small racquet-shaped addition made upwards to include the opening of the fistula, and the upper flap turned up towards the mandible. The tract was a firm and well-defined cord-like structure, and easily separable from its bed in front of the body of the hyoid bone. It disappeared under the anterior belly

of the right digastric muscle, just in front of the intermediate tendon (*Fig.* 489). The tract was ligated with stout silk just below the anterior belly of the digastric, the lower part removed, and the stump touched with carbolic, then alcohol, and dried. The skin was then closed.

Fig. 490 shows a microphotograph of a transverse section of the tract; note the mucous gland opening into it.

SUBSEQUENT PROGRESS.—Since the operation three and a half years ago, the patient has had no trouble. There has been no sign of recurrence, and the tract has now found a normal outlet for its secretion in the pharynx. The patient was shown at a meeting of the N.S.W. Branch of the B.M.A. held at St. Vincent's Hospital in September, 1935.

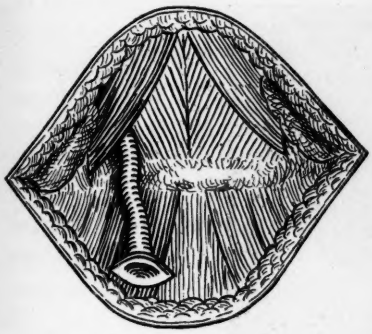


FIG. 489.—*Case* 1. Drawing of operative findings.

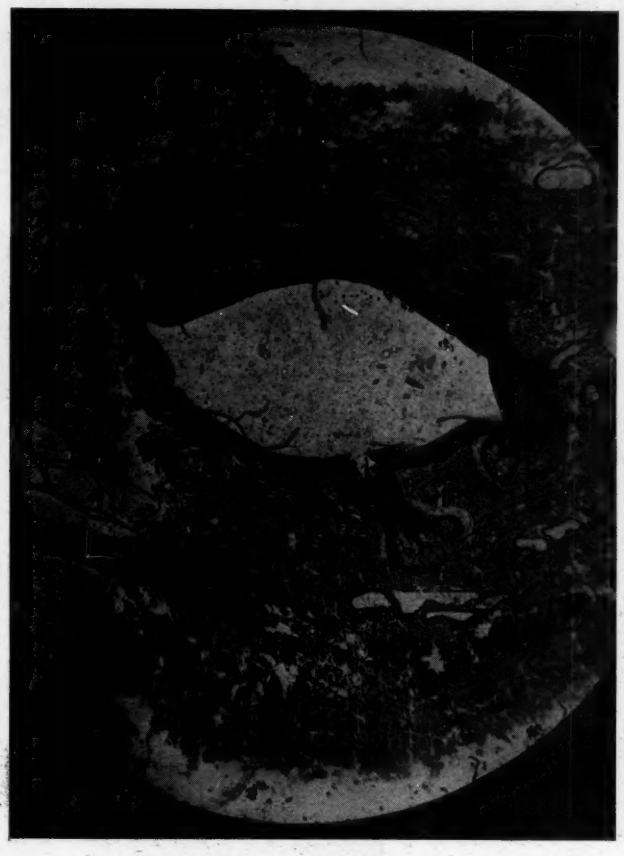


FIG. 490.—*Case* 1. Microphotograph of tract.

Case 2.—The next patient, W. F., a youth aged 16 years, complained that six years previously he had slipped in the bath and bumped the front of his neck. He could not definitely remember if there had been bruising. However, within a few days of the bump, a lump appeared and was lanced soon afterwards. The wound had ever since been covered by a scab. The tract may fill up and become painful. It discharged pus intermittently. (It is of some interest to note that trauma, either a direct blow or coughing, is not an uncommon precursor of the lump. Other patients note that some infection, influenza, or a cold, precedes the appearance of the lump.)

ON EXAMINATION.—The broad scar of the previous operation, with an opening in the centre of it, was found above the hyoid bone. The tract could be felt to pass from the skin opening, but could not be traced far. The isthmus of the thyroid gland could not be definitely palpated in its normal position.

X-ray Examination.—After injection with iodized oil (*Fig.* 491) a radiograph showed the tract passing downwards, then upwards in front of the body of the hyoid, then arborizing richly in the posterior third of the tongue musculature, and opening at the foramen cæcum. Iodized oil can be seen in the pharynx. This radiograph provides a probable explanation of the numerous transections of the tract shown in *Fig.* 485, and probably in that case also the tract arborized richly in the tongue musculature.

AT OPERATION.—The X-ray study showed that if an attack on this fistula were to be carried out above the hyoid bone, no half-measures would suffice. Remembering the delicate

structure of the tract with its branches lined by but a single layer of epithelium, it is clear that complete removal could be achieved with certainty only by including a wide margin of tongue musculature. It appears therefore that at least one-third of the tongue in its posterior part would need excision. But it would be hard to justify such a radical procedure for a comparatively innocuous lesion. Any lesser interference above the hyoid bone, such as Sistrunk's operation, is obviously inadvisable, because outlying parts of the tract would almost certainly ensure later cyst formation. It was therefore decided to remove the tract from the skin opening to the upper border of the hyoid, and to ligate the lower end of the remainder. It was hoped that only the lower part of the tract was responsible for the fistula (through traumatic separation from the pharyngeal opening), and that now the pharyngeal opening would again prove adequate, as it probably was for ten years before the injury.

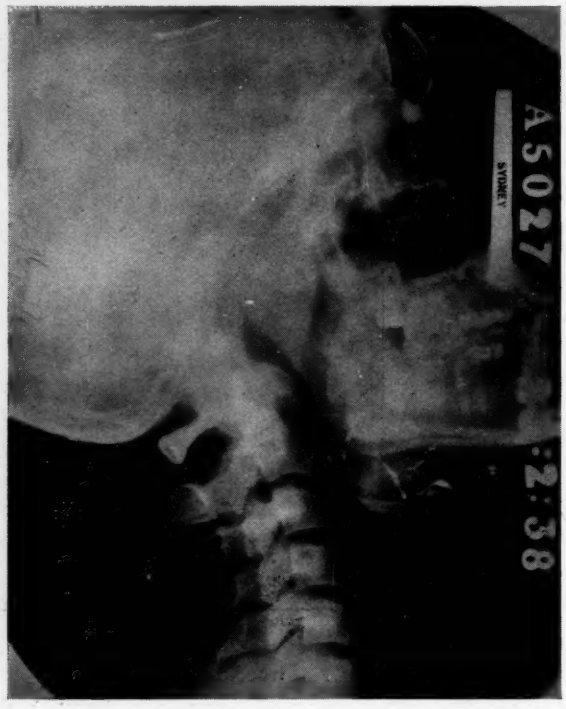


FIG. 491.—*Case* 2. Radiograph of tract.

This operation was carried out at St. Vincent's Hospital in March, 1938. (A short transverse incision was first made in front of the trachea and a search made for the thyroid gland. No isthmus could be found, but the lateral lobes were well developed.)

SUBSEQUENT PROGRESS.—About five months after the operation a swelling recurred in the neck and discharged through the operation wound. I have advised against any further surgical attempts at cure of the condition, and have sent the patient for radiotherapy in the hope of inhibiting the secretory activity of the tract. As yet it is too early to assess the results.

DISCUSSION

A point of interest is the relationship between the thyroglossal tract and the hyoid bone, differing descriptions of which are given by different anatomists.

Parsons states that the tract passes through the hyoid; Frazer says in front of the hyoid; Rose and Carless show it passing behind the hyoid; and Keith says that the hyoid bone develops in the course of and interrupts the continuity of the thyroglossal tract. In the case of the baby mentioned the relationship of the tract to the bone was not definitely determined; in *Case* 1 the fistula could be rolled on the anterior surface of the bone, and at operation lifted easily off the bone; and in *Case* 2 the radiograph shows the tract in front of the bone.

The cases described are of interest also from an embryological point of view. *Case* 2 and that of the baby represent a racemose type of fistula in which the median thyroid rudiment has branched above the hyoid; *Case* 1 represents a tubular type in which the median thyroid rudiment has branched in the normal position, but the stalk has failed to undergo obliteration. *Case* 2 indicates the importance of the ultimate branchial bodies in forming the lateral lobes of the thyroid gland. These small cellular bodies arising from the fifth pharyngeal pouch were given their due importance at the beginning of this century, but later they became discredited and were said to degenerate, leaving no vestige. Cunningham's *Text Book of Anatomy* (1917) said, "their chief interest is that, for long, they were erroneously regarded as the rudiments of the lateral lobes of the thyroid gland". But now embryologists have reinstated them, and the second case lends support to the present-day view.

In *Cases* 1 and 2 treatment has been based on the belief that the thyroglossal tract should give no trouble if it has a patent pharyngeal end, a closed skin end, and a complete epithelial lining. Under these circumstances the tract should be no more likely to become obstructed with cyst formation than should the parotid and submaxillary salivary glands. The importance of an epithelial lining in determining the behaviour of a fistula needs no emphasis. If the lining is intact the fistula tends to remain patent, but if the lining is in whole or in part made of scar tissue, the tendency is for contracture and closure to take place. If two closed segments (or strictures) cut off between them an unobliterated part of the tract, then abscess or cyst formation results. In *Case* 1 the outlook for permanent cure is good. The radiograph shows the pharyngeal opening to be free, the tract simple and well defined, and the absence of history of recurrent cyst formation suggests that the tract is free from strictures. The outlook in *Case* 2 was not hopeful, because the history suggested a stricture in the tract, and the radiograph showed its delicate arborizing nature, with narrow pharyngeal opening. If injection of thyroglossal fistulæ by iodized oil (preferably a thin oil, such as neo-hydriol) and subsequent radiography were a routine procedure, it is possible that a large proportion would be found to have a pharyngeal opening. If there is such an opening it would appear that the procedure of election is ligation of the tract, taking care not to damage the upper portion, lest delicate branches be separated from the main trunk. The operation is a minor one, which can be carried out in a few minutes under local anæsthesia, and the risk of infection is minimal as compared with the method whereby the wound is carried through into the buccal cavity. If it fails, more radical procedures (operative or radiotherapeutic) can be carried out later.

A further reason for the routine use of radiography is that the tract may pass downward toward the thyroid gland, and necessitate a differently planned incision.

CONCLUSIONS

1. The complete thyroglossal tract does occur, and may form a considerable percentage of all cases.

2. Two types occur, the tubular and the racemose. These differ in their embryological significance and in their surgical difficulties.

3. X-ray examination of the tract should be done as a routine.

4. Treatment and prognosis should be based upon the radiograph.

5. If the fistula is complete, cure may be obtained by ligation, especially in the tubular type.

6. The cases here recorded are helpful in the study of the anatomy of the thyroglossal tract and of the embryology of the thyroid gland.

REFERENCES

[1] CRILE, G., and associates, *Diagnosis and Treatment of Diseases of the Thyroid Gland*, 1932. Philadelphia and London: Saunders.

[2] SEMKEN, G. H., *Nelson's Loose-Leaf Surgery*.

THE CLOSED OPERATION FOR INTRACAPSULAR FRACTURE OF THE NECK OF THE FEMUR

FINAL RESULTS IN RECENT AND OLD CASES

By THOMAS KING

ORTHOPÆDIC SURGEON, ST. VINCENT'S HOSPITAL, MELBOURNE, AUSTRALIA

THIS study consists of two parts, the first of which is concerned with recent fractures, and the second with old fractures. Lateral, basal, or trochanteric types of fractures are excluded from this report.

I. RECENT FRACTURES (UNDER THREE WEEKS)

This is an individual study of the first 50 consecutive fractures examined at least one year after the operation. Nearly half the cases have been re-examined after three years. The results are as follows :—

Non-union	3	(6 per cent)
Osseous union (X-ray)	37	(74 per cent)
Death (under one month after operation)	6	(12 per cent)
Death in first year (before union known)	1	(2 per cent)
Result unknown for certain	3	(6 per cent)
Total	50	

Comment.—Osseous union was obtained in 74 per cent of all cases, but if deaths and unknown results are excluded, osseous union occurred in over 90 per cent of cases. Degenerative changes in the caput femoris causing osteo-arthritis following osseous union occurred in 14 (28 per cent); the condition will increase with time; most of these have little trouble at present. Therefore over one-third of the patients with osseous union developed osteo-arthritis (severe and mild). The nail failed to hold in the head in 4 cases (8 per cent), and in two of these cases a new nail and fibular graft (*see Table III, Cases* 1 and 6) were inserted with success; and in two a nail was reinserted, only one being successful.

Selection of Patients for Operation.—Some hospitals refuse to accept patients if they are too old or frail, and therefore these institutions will provide good results. To gauge the real value of this method every type of case should be accepted. Unless the individual was bedridden or moribund, every intracapsular fracture under my care since August, 1933, has been treated by operation. Only 13 were refused operation. Some were operated upon at the request of the Ward Sister because of impending bed-sores (skin discoloration over the sacrum), and none of these died. I withheld operation always when the temperature was raised or pulmonary changes were present.

E. I. Lloyd warns against attempting to cure pneumonia in moribund old women by nailing, but Brittain advises it, whilst Thornton and Sandison also do not defer operation on this account and they record no deaths in sixty patients.

Sixteen patients between 80 and 98 years old have been operated upon by me, and only 2 died. Old people with this fracture fear every movement because it is painful, and therefore lie quiet on their backs, so that a pressure sore sometimes develops within twenty-four hours. Nursing is difficult and pressure sores are often unavoidable. For these people operation carries a greater risk than in individuals under 60, but it may be life saving. As the operation is not dangerous, it is humane to operate and relieve their pain, which disappears twenty-four to forty-eight hours after operation, permitting nursing them in the lateral or Fowler positions. The old practice of sitting them out of bed almost immediately, and despite non-union, was cruel and harmful. Many of these poor old people are absolutely unsuited for the long and uncertain ordeal of a plaster spica, or even a Jones abduction frame or any other method of external splinting where recumbency is necessary for the conservative method of treatment of the fracture (especially the large plaster apparatus); and also for osteotomy in recent fractures, now advocated by Ettore and McMurray—if these surgeons only use osteotomy for treating fractures of the femoral neck, they will be obliged to refuse treatment to most of the patients over 60. In my first 50 cases there were only 9 under 60 years of age.

Never before have so many fractured femoral necks been treated with the object of obtaining osseous union, and the general mortality has not been increased by operation (e.g., in my first 100 consecutive cases, 73 were operated upon, with 8 deaths; 13 were refused operation, and all but 2 died; 14 were impacted fractures, with no deaths—i.e., 19 per cent mortality of all cases). Bucheim reported that until 1933 at the Leipzig University Clinic all fractures of the femoral neck were treated conservatively, with a mortality of 42 per cent. Felsenreich had a 28·7 per cent mortality of all cases, made up as follows: 11·5 per cent operative mortality within about one month; 10 per cent deaths following operation in first year; 7·2 per cent deaths with no treatment. Therefore this fracture is often the death-blow to an old individual; and it is no wonder that other complications, e.g., non-union or degeneration of the head, are of such frequency and make this both the most serious and difficult fracture we attempt to treat. Nevertheless the fracture has to be dealt with as best we can, especially as it occurs sometimes in valuable young lives; also those who have reached the age of three score and ten do not as a rule wish to retire immediately to another world because they have broken their hip if there is a prospect of cure, and in most cases the relatives also wish to preserve the life of their old parent. Up to the present I have never seen the necessity for interfering with a true impacted fracture, i.e., Group 1 (Pauwels) with coxa valga; nor any insecurity of the impaction which required nailing. It is impracticable to correct the unimportant external rotation, which could never be very great in a real abduction or impacted fracture; any correction by internal rotation would result in a V-shaped gap on the posterior aspect of the neck due to the crushing.

The Obliquity of the Fracture Lines.—The important work of Pauwels sets out to prove that the problem of obtaining osseous union in recent or old fractures of the femoral neck relies on avoiding the shearing and adduction strain which depends mechanically upon the obliquity of the fractured surface to the horizontal plane. This view, at the present time, has captured surgical imagination throughout Germany. Unfortunately Pauwels did not consider the equal importance

of the external rotatory force causing a separating of the fragments, and thereby being an important source of non-union. The horizontal plane is represented by a line through both anterior superior iliac spines. Depending upon the angle formed between the fracture line and the horizontal plane, three grades of fractures are recognized (*Fig.* 492):—

Group 1.—The truly impacted or abduction fracture in coxa valga position forms an angle of 30°–0°, i.e., the fractured surfaces are almost horizontal, and osseous union invariably follows because a shearing force due to muscle action or

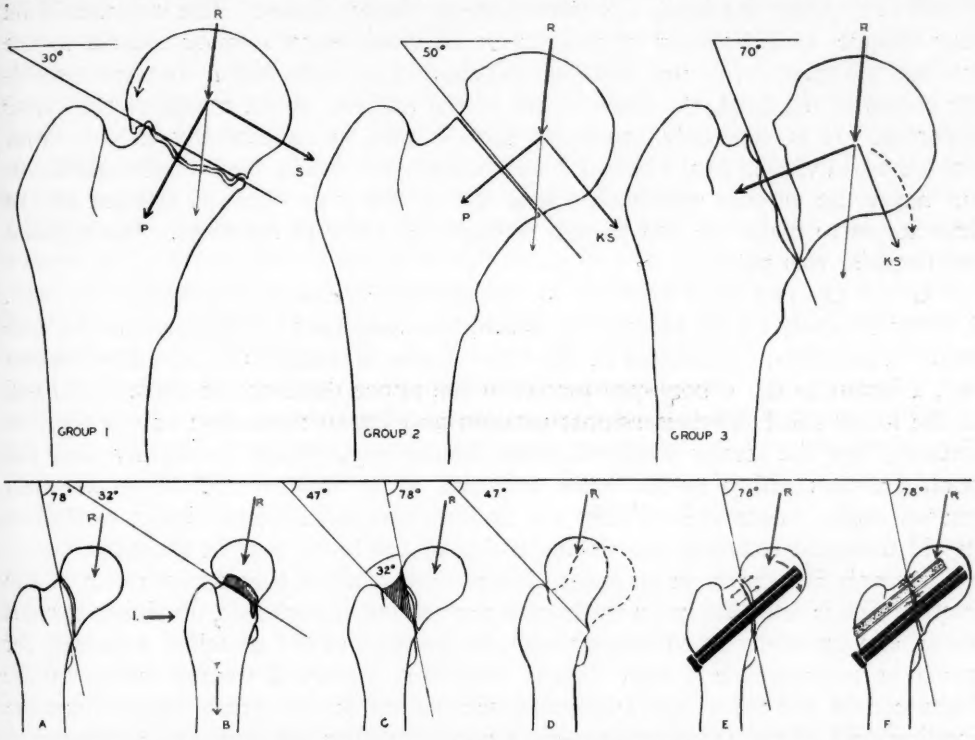


FIG. 492.—TOP.—Diagram showing Pauwel's three groups. R, Weight-bearing force (parallel with trabecular lines in femoral neck); S, Potential shearing force (parallel with fracture line); P, Pressure force which impacts (90° to fracture line); KS, Active shearing force which passes medial to fracture and tilts head with adduction deformity.

Group 1: Fracture line is less than 30° to horizontal (patient standing), i.e., impacted fracture. No shearing (KS) occurs; good prognosis; nailing unnecessary. *Group* 2: Fracture line 30°–50° to horizontal. Shearing occurs unless fracture is nailed. *Group* 3: Fracture line 50°–90° to horizontal, i.e., vertical type. A long 'spike' usually attached to caput femoris; bad prognosis, even with nailing, unless a solid fibular peg is also used in upper third of femoral neck (*see* E, F, *below*).

BOTTOM.—A, *Group* 3 fracture. B, *Group* 3 converted into *Group* 2 fracture by overtraction (T) and impaction (I) C, D, *Group* 3 fracture converted into *Group* 2 by intra-articular excision of wedge (Voss); to be condemned (47° should be 46°). E, *Group* 3 fracture nailed in lower third where bone is denser; marked tendency to shearing and cutting out of nail. If nail inserted in upper third less tendency to shearing, but bone is too soft to hold nail. F, Author's method of dealing with *Group* 3 fracture. Fibular peg in soft upper third where osseous union is slow, and nail in dense lower third.

weight-bearing does not exist. Many patients with such a fracture walk for weeks or months before the exact nature of the injury is discovered. Whilst the early weight-bearing is harmful because it favours the subsequent development of osteo-arthritis, it does not tend to cause displacement by a shearing force; but muscle pull alone, with a patient merely lying in bed, causes displacement by a shearing force in fractures of *Groups* 2 and 3. Operation is absolutely unnecessary in *Group* 1 fractures.

Group 2.—The fracture line forms an angle to the horizontal plane of 30°–50°. In these cases the effect of a Smith-Petersen nail or other transfixing apparatus is to prevent shearing, quite apart from holding the fragments together and preventing rotation between them. Another function of the nail is to prevent tilting of the head. In order to prevent this the nail would be better placed in the upper third of the neck instead of in the lower third, which is generally selected because the nail has a more effective hold in the denser bone near the calcar femoralis. The nail should penetrate the caput femoris near the fovea, so that a maximum length of nail is gripping the head, as pointed out by Watson-Jones. The nail should be very oblique, i.e., it should be inserted at least one finger's breadth distal to the trochanteric tubercle, so that although the sharp end of the nail is directed towards the centre of the head, the main length of the nail lies in the region of the calcar femoralis. It is especially important for the nail to be centrally in the caput femoris when viewed in the lateral X-ray picture, or even in the posterior quadrant, but never the anterior quadrant, where the tendency to outward rotation of the limb serves to make the nail plough through the front of the head. Pauwels did not consider this point.

Group 3.—The angle made by the fracture line is now almost vertical, 50°–90°. A study of nearly all my failures has shown that they have belonged to this vertical group of fractures. Therefore in this type of case, in addition to a Smith-Petersen nail, I began to use a bone-peg placed in the upper third of the neck. The nail in the lower third provides against rotation and lateral separation of the fracture surfaces, but the strong whole-thickness fibular peg, which fits tightly into the head, prevents tilting of the head and coxa vara, besides stimulating an early osseous union. Almost invariably the fracture line has become almost vertical in an old ununited fracture, due to absorption of the lower part of the neck.

Pauwels has shown in his most scientific monographs that this problem of the fracture line is one that has a theoretical dominating influence in obtaining osseous union, and especially when dealing with the problem of old ununited fractures, for which he recommends a high Schanz osteotomy. Even if osseous union of the fracture does not follow the osteotomy, the patient derives great benefit from the 'reclination' of the fracture line—pain and instability are improved or disappear in patients under 60.

Method of Anæsthesia.—Although spinal and general anæsthesia were used at first, more than 70 cases have been operated upon most satisfactorily under local analgesia, but admittedly they were generally semi-conscious under the influence of hyoscine and morphine, which have no harmful after-effects. Forty c.c. of 0·05 per cent percaine (which produces prolonged analgesia) is injected into the upper aspect of the hip-joint proximal to the tip of the great trochanter. The distension of the hip-joint should prevent the intervention of synovial folds and the retinacular fibres, and thereby facilitate the reduction. Two hundred c.c. are injected over the lateral aspect of the upper end of the femur. Ether or gas anæsthesia of a few minutes' duration is generally sufficient whilst the patient is lifted on to the orthopædic table and the fracture reduced. Prolonged general anæsthesia and spinal analgesia are dangerous. The patient is wrapped in warm blankets. Most of the post-operative deaths were due to the fracture and not to the operation, and were probably inevitable. Pneumonia occurring after two weeks can hardly be attributed to the operation, yet I have included all deaths within

the first month after operation in the post-operative mortality. In *Table I* there are 6 deaths following operation; every death was due to the poor general condition of the patient except *Case* 48, which was due to streptococcal infection of the wound. In 130 operations there were 3 cases of infected wounds. There were only 2 deaths in 42 operated old ununited fractures (30 of which are reported later), which shows that the fracture and not the operation causes the death in recent fractures.

Reduction.—Failure to reduce the deformity is very rare. This occurred in only one case, and was due to excessive preliminary traction in the ward causing elongation of the capsule, etc., so that the femoral neck and head could not be controlled by the usual manœuvres. At open reduction there was no other cause discovered. This fracture failed to unite by the nail and so a fibular graft was inserted later by the extra-articular method. A perfect reduction is generally essential, and, fortunately, nearly always easy to obtain. Nevertheless union has occurred when the neck has still been displaced forwards. In this case the nail slipped, and, as the callus was not ossified, the neck bent and the head became retroverted. To obtain a good reduction the neck should be pressed back powerfully with the thumbs and the trochanter lifted forwards while the fractured surfaces are separated strongly by a lateral pull with a sling around the adductor region, and an assistant strongly rotates the foot. Over-traction can be avoided by using manual traction for controlling the shortening (always slight), and the orthopædic table is merely used to hold the limb. Slight over-traction has been recommended by Hey Groves, Henderson, Smith-Petersen, and others because the coxa valga position which results, favours osseous union by altering the fracture line to the horizontal (Pauwels) and good function is not affected thereby, but this position of coxa valga favours subsequent degenerative changes in the head. Any imperfection of reduction means that fractured surfaces are exposed and have no blood-supply (except by synovial adhesions to the raw surfaces), thereby predisposing the bone in that region to local necrosis and degenerative changes in the caput femoris, causing traumatic osteo-arthritis later.

X-ray Evidence of Osseous Unions.—Premature weight-bearing, i.e., before osseous union, is absolutely wrong, even though it may not cause a re-fracture, because it favours development of degenerative changes in the caput femoris. Whilst the pressure effect of weight-bearing on the regenerating bone may favour osseous union in any impacted fracture (whether self impacted or by the surgeon) it is to be strongly condemned. Osseous union may not be complete in even three or six months (*Figs.* 493–498), and until this occurs the nutrition of the head is defective. It is complete only when trabeculations transect the old fracture site. Almost invariably this occurs first in the lower part of the neck where the pressure zone (Pauwels) exists, but in the upper part of the neck there is a tendency for the fracture to separate (*see Fig.* 492). Weight-bearing before the upper part has united may not result in absolute failure, but does tend to cause an alteration in the neck-shaft angle (coxa vara) and favours degenerative changes in the upper quadrant of the caput. In Johansson's monograph there are eight cases claimed as "osseous union" or "doubtful union", but on studying the X-ray pictures I think five, at least, are undoubted non-unions (Cases 7, 27, 30, 37, 47). In Pauwels' book, where he sets out to prove that osseous union is a mechanical problem in which we merely must convert a shearing force into a pressure force by making the

fracture line more horizontal, some of his X-ray pictures do not show the osseous union claimed, and there is not one lateral X-ray picture because his mechanical theory does not take into account external rotation as a cause of re-displacement, as shown in *Cases* 42 and 46 in my paper. (*Figs.* 499–504.) In some female cases this fracture is a pathological one, with softening of the femoral neck due to some unknown cause. Autopsy reveals a fatty degeneration in the neck and the head,

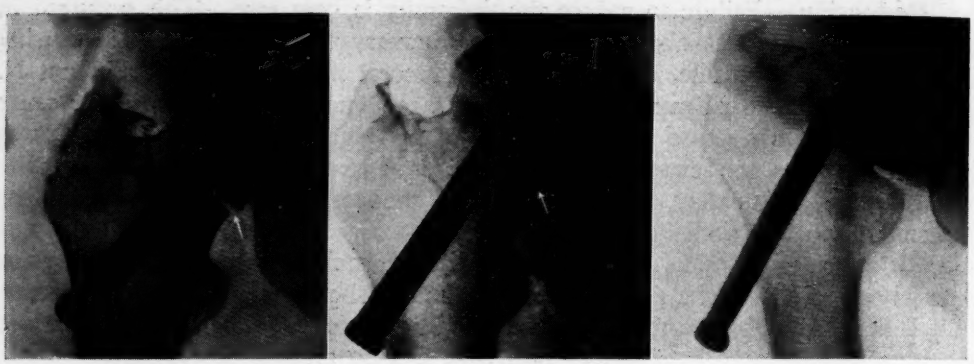


Fig. 493 *Fig.* 494 *Fig.* 495

FIG. 493.—*Case* 52 (aged 83). Radiograph taken Aug. 3, 1937, immediately after operation. Note gap across calcar femoralis.

FIG. 494.—Same case. Radiograph taken Nov. 3, 1937. After 3 months, note the new subperiosteal bone and closing of gap.

FIG. 495.—Same case. Radiograph taken Nov. 24, 1937. Weight-bearing 3½ months after operation caused this separation, which might have been avoided by waiting until there were well-marked trabeculations across the fracture line (6 to 9 months).

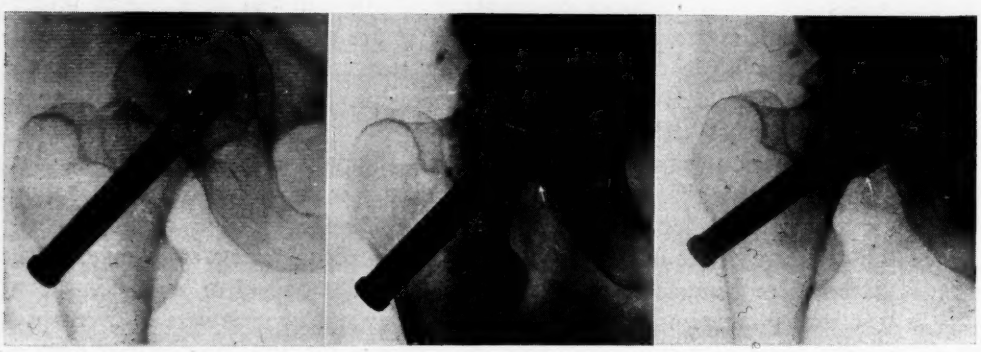


Fig. 496 *Fig.* 497 *Fig.* 498

FIG. 496.—*Case* 14 in *Table II* (aged 70). X-ray view on day of operation, May 2, 1937, 7 weeks after fracture (March 10, 1937).

FIG. 497.—Same case. The appearance on July 30, 1937, 3 months after operation. Union is not present.

FIG. 498.—Same case. Radiograph taken Nov. 3, 1937, 6 months after operation. Osseous union has occurred along calcar femoralis, but no union in upper part of neck, where osseous union is always delayed. Only after 9 months was osseous union complete and weight-bearing permitted.

which in cross-section show islands of fat producing a mottled effect; the upper end of the femoral shaft near the base of the trochanter is vascular and so soft that it can almost be cut with a knife. The result of any method of treatment here is problematical. There should be an X-ray examination every six weeks for three to six months, so that nail slipping (rare) can be corrected.

Fig. 499

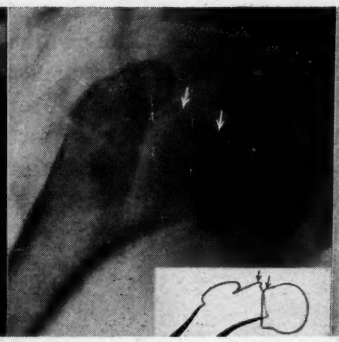


Fig. 501

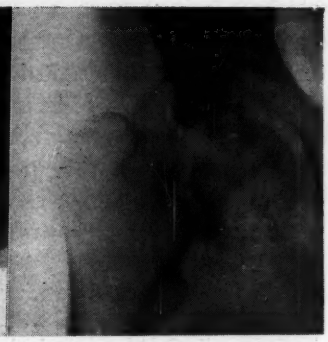


Fig. 503

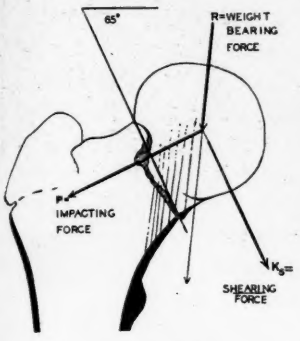


Fig. 500

Fig. 502

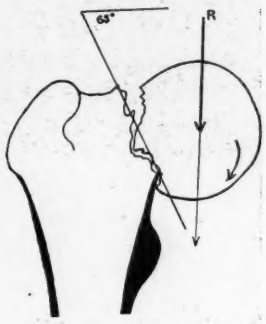


Fig. 504

FIGS. 499, 500.—*Case* 5, *Table III* (aged 13½). May 18, 1936. Control X-ray picture after reduction and Whitman cast. Although no lateral X-ray examination, reduction seems good; *Group III* fracture (Pauwels), because line R, which passes through the head parallel with the trajectory lines of force, falls medial to the fracture line, which makes an angle of 65° with the horizontal line joining the iliac crests.

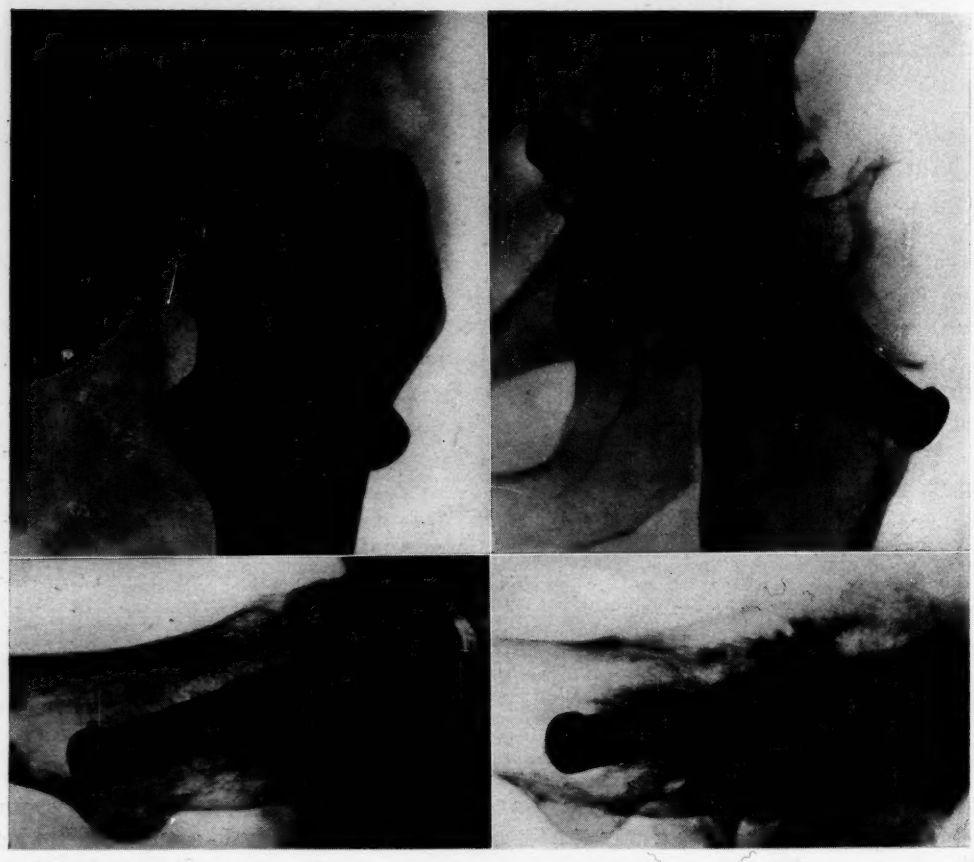
FIGS. 501, 502.—Same case. June 23, 1936 (5 weeks later). Still in the Whitman plaster spica, but shortening and external rotation have developed. It is impossible to say whether the shearing seen in the frontal view developed first according to Pauwels' theory, or the external rotation of the femoral shaft seen in the lateral view, which he has not considered.

FIGS. 503, 504.—Same case. Aug. 17, 1936. On removal of the cast the X-ray picture shows not only non-union, but a pseudarthrosis with sclerosed fractured surfaces and absorption of the upper third of the neck. This fracture in a child behaves just as badly as in adults.

Failure of Nail to Hold in Caput Femoris.—To avoid the well-known slipping of the nail out of the caput femoris so that the nail head can be felt under the skin, a small rustless nail driven into the shaft distal to the nail head has been suggested by Pidcock, Felsenreich, and others. Originally I used a fibular peg if this occurred, and now I use them as a routine in all cases from the start, as well as a nail. Johansson and Eric I. Lloyd notched the nail. In a personal communication Smith-Petersen informs me that he tried plugging the counter-sunk nail head with bone. Other suggestions (caps, etc.) are impracticable. When the nail slips or cuts out of the caput, another nail should be inserted along a different track in the lower part of neck and caput and a solid fibular peg in the upper part. A firmer fixation and more rapid osseous union thereby results.

Weight-bearing.—Early weight-bearing, i.e., before the fracture has firmly united, is one of the worst mistakes that many of us made, and some experienced surgeons are still making it. Even in an impacted fracture with coxa valga and in which early weight-bearing may not cause any displacement of the fracture,

weight-bearing down on a devascularized head must almost inevitably provoke degenerative changes in the cartilage and bone. Now I never allow weight-bearing under three to four months, and often only after six months, which is a safer time to allow walking. It is only allowed when a well-formed head has united firmly, as indicated by cross trabeculations at the old fracture site. This may require nine months (*Figs.* 496–498). *Figs.* 493–495 show a failure due to allowing weight-bearing at three and a half months. To avoid the shearing strain whilst lying in



Figs. 505, 506 *Figs.* 507, 508

FIGS. 505, 506.—*Case* 9, *Table I* (aged 64). Radiograph on Dec. 28, 1934, 1 month after operation. Coxa valga is present due to slight overtraction plus impaction. Note the comminuted caput femoris. Although patient walked well after 6 weeks, this type of fracture should not be allowed to bear weight under 6 to 12 months.

FIGS. 507, 508.—Same case. X-ray appearance, Sept. 5, 1937, nearly 3 years later. Able to walk 1 mile with stick; moderate pain. Osseous union is proved by lateral X-ray view. The nail penetrating the pelvis was removed. Absolute stability of the hip-joint and fair function is present, despite severe necrosis of caput femoris caused or accentuated by early weight-bearing on a crushed head.

bed, the limb should never be adducted, and meals should be served on a table at the side of the bed corresponding to the fractured hip. Undoubtedly a failure of the nailing to secure osseous union has often been caused by early weight-bearing. (*Figs.* 505–508.)

Function.—If osseous union results from the operation, then the surgeon has done all that is humanly possible to obtain a satisfactory functional result, provided

that the limb has been merely exercised and early weight-bearing been forbidden. The range of hip movement is not very important so long as it is adequate, but knee movements should be normal. When the hip-joint is stable and movement is painless, the stooping and limping so commonly seen can be disregarded. In relatively few instances was normal function restored. Nevertheless the general results of extra-articular osteosynthesis, when compared with the dreadful results of non-union, justify our perseverance with this valuable and gentle method. In *Table I* " function " in 37 cases with osseous union was :—

Normal: Perfect—12 (24 per cent).
Good: Walk one to three miles, slight limp, and occasional ache (change of weather)—13 (26 per cent).
Fair: Walk about house, slight pain, limp, and stoop—8 (16 per cent).
Poor: Severe pain and inability to walk except few yards—3 (6 per cent)
Bad: Confined to bed or chair—0.
Also 1 case with osseous union at autopsy had not walked.

The Value of the Bone-peg Plus the Nail.—Although in these 50 recent fractures the fibula graft was not used in conjunction with the nail, I always use this combination now in recent fractures as well as in the old fractures, i.e., over three weeks old. Osseous union is more rapid and certain, and as a result I think there are now fewer cases of degeneration of the caput femoris, because it is obvious that delayed union, when the nail alone is used, favours poor nutrition of the head. After about three months the nail is usually loose. If the callus formation is not yet strong enough to hold the two fragments together, weight-bearing may now result in the nail sliding or cutting out, with inevitable re-fracture. The only good purpose of the nail is to hold the caput femoris until this is revascularized by the blood-vessels from the cancellous femoral neck, which is almost entirely responsible for ossification at the fracture site. The nail cannot be blamed for destroying blood-vessels, e.g., from the ligamentum teres, because it is so thin. Although Albee said, " In my opinion our waning faith in nails is not going to be restored by changes in the shape of the nail ", the nail has almost solved the problem of sound fixation until union is solid, but of course it in no way directly influences osseous union ; moreover if it is not absolutely stainless, the nail may have an unfavourable effect. The loosening of a good nail (almost unavoidable after three months), is never associated with marked absorption of bone beyond that district immediately in contact with the nail. Whilst loose, it should not wobble. Felsenreich has shown by autopsy specimens (paper not published) that when the nail has been removed, the granulating track may subsequently become ossified. In one case he found that the nail was surrounded, not by a granulating wall, but by a bony wall. Therefore if we insert a fresh bone-peg across the fracture site from the upper end of the femur into about one and a half inches of the caput femoris, this new bone promotes ossification as well as supplementing the security of fixation obtained by the stainless nail, especially in *Group* 3 fractures. (*Fig.* 509.)

At first I used the combined nail and graft only for ununited fractures of the femoral neck (over three weeks old) ; then in *Group* 3 fractures ; in young people, where every method of obtaining osseous union should be used ; also when the nail failed to hold the fragments together. Lately I have been using it in all cases. The nail also may cut out of the head because it has been placed in the upper or anterior soft quadrants of the caput ; the nail may be too short ; the caput may

be atrophic, in which case I invariably at the second operation drive the nail through the centre of the caput (fovea) into the soft tissue and fat which fill the depth of the acetabulum. Thereby no harm results, such as increased danger of caput necrosis, pain, or limitation of movement, because only the rim of the acetabulum articulates directly with the caput and this is unaffected by a central nail. More commonly the nail slides out below the trochanter, and then the bone is usually atrophic and osseous union is slow. Therefore the stimulating effect of a fresh bone transplant is important. When the lateral X-ray picture shows a comminuted caput or a wedge defect in the posterior aspect of the neck due to crushing, a bone-peg should always supplement the nail; otherwise union will be very slow and the head may slowly rotate behind the neck as the nail loosens. Finally the

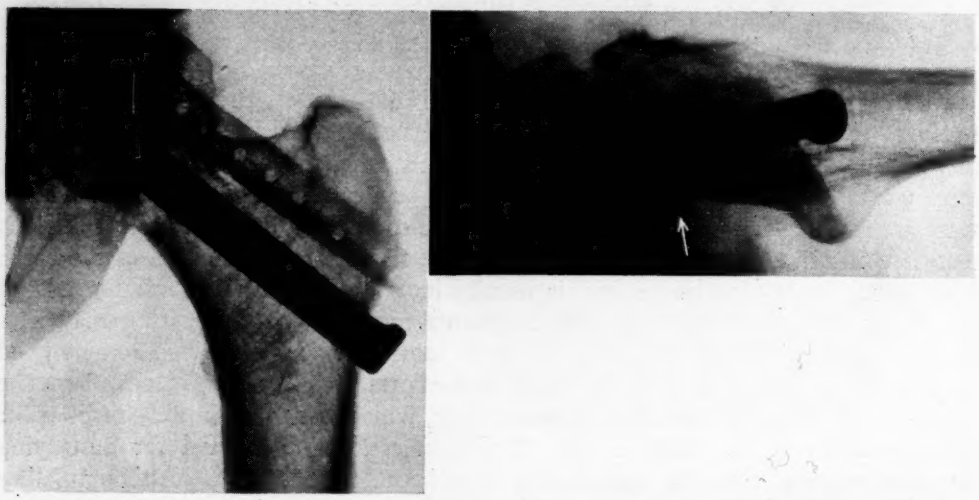


FIG. 509.—*Case* 74 (F., aged 52). Fracture on Aug. 14, 1938; operation on Aug. 18, 1938—Smith-Petersen nail in lower part of neck aimed from the lateral aspect of the femoral shaft towards the centre of the head; strong fibular graft, drilled in many places along its length, in the upper part of the neck. This graft favours more rapid osseous union in the upper part of the neck, where osseous union is always slower than in the lower part. Thereby the danger of degenerative changes in the caput are minimized, because slow union means poor nutrition of the head. Note the comminuted fragment in the back of the neck in the lateral view. The combined Smith-Petersen nail and fibular graft is suitable not only for old fractures, but also for some recent fractures.

vascularization of the graft acts as a special and accessory channel for the entry of blood-vessels into the head, especially into its most proximal part. The fibular graft is hollow and contains a medullary cavity one-quarter of an inch in diameter packed with spongiosa. When the fibular peg is scraped of all muscle attachments, numerous pin-point vascular foramina stud the cortical surface of the bone. It is a splendid bone transplant. Although the caput consists of cancellous bone, it is very dense. The half-inch drill hole in this dense spongiosa for reception of the fibula peg increases the area of the caput femoris which can be revascularized.

Degenerative Changes in the Caput Femoris Causing Osteo-arthritis.—The head of the femur is the vitally affected structure of this weight-bearing joint, and therefore any necrosis or subsequent irregularity of the head must result in secondary arthritic changes involving the synovial membrane, acetabulum, etc., i.e., secondary or traumatic osteo-arthritis. Then the acetabulum, especially its upper part, alters to conform with any change in the shape of the head; the neck

Table I.—Details of 50 Cases of Extra-articular Osteosynthesis with the Smith-Petersen Nail for Recent (under 3 weeks) Medial Fractures

Case No.	Age and Sex	Pre-operative Complication	Date of Fracture	Date of Operation	Weight-bearing after Operation	Osseous Union (X-ray)	Function	Comment
1	74 F.		August, 1933	(3 days)	2 days	No	Bad	Too early weight-bearing
2	48 M.		September, 1933	(4 days)	6 weeks	Yes	Normal	Aug. 30, 1937: "No effect with leg". Works as boiler-maker
3	74 F.		Sept. 4, 1933	Sept. 8, 1933 (4 days)	5 weeks	Yes	Good	No pain—walks well (March, 1936)
4	71 F.		Sept. 9, 1933	Sept. 12, 1933 (3 days)	3 weeks	No	Bad	Nail not inserted centrally in caput femoris
5	64 F.	Poor subject	Jan. 15, 1934	Jan. 18, 1934 (3 days)	—	—	—	Death Jan. 23, 1934—5 days. Pulmonary embolism
6	64 F.		July 6, 1934	July 13, 1934 (7 days)	3 months	Yes	Good	March 11, 1938: walks 1–3 miles— no pain except weather, despite *osteo-arthritis*
7	52 F.	Bronchopneumonia (7 days)	Sept. 25, 1934	Oct. 10, 1934 (15 days)	3 months	Yes	Normal	"Walks miles", March 2, 1938
8	74 F.	Bronchopneumonia	Oct. 28, 1934	Nov. 14, 1934 (17 days)	7 weeks	Yes	Fair	Nail in rim of acetabulum—*osteo-arthritis*, 1936
9	64 F.	Shock	Nov. 12, 1934	Nov. 28, 1934 (16 days)	5 weeks	Yes	Fair	Almost complete *necrosis of head*—walks 1 mile with stick—moderate pain—Oct. 4, 1937, nail removed (*Figs.* 29–32)
10	74 F.	Pneumonia	Nov. 29, 1934	Dec. 18, 1934 (19 days)	5 weeks	Yes	Good	Died, cerebral hæmorrhage, 1937,
11	67 F.	Weight 16 st. Vertical fracture (Pauwels)	Feb. 21, 1935	March 3, 1935 (13 days)	5 months	No	Bad	Nail cut out of caput, second operation 2 nails—failure
12	84 F.	Cystitis and incontinence	Feb. 19, 1935	March 7, 1935 (19 days)	None	Yes	—	Death, carcinoma bladder, 5 months later—autopsy: osseous union
13	72 F.	Urinary incontinence	March 3, 1935	March 8, 1935 (5 days)	6 weeks	Yes	Fair	Second operation nail and graft Nov. 28, 1935—improving. Sept. 8, 1936: *osteo-arthritis*
14	74 F.		April 20, 1935	May 1, 1935 (9 days)	6 weeks	Yes	Normal	Perfect Aug. 10, 1936
15	70 M		May 13, 1935	May 29, 1935 (15 days)	6 weeks	Yes	Normal	Working as gardener, May 1, 1938

[*Continued on next page*

Table I—Details of 50 Cases of Extra-articular Osteosynthesis with the Smith-Petersen Nail for Recent (under 3 weeks) Medial Fractures—*continued*

Case No.	Age and Sex	Pre-operative Complication	Date of Fracture	Date of Operation	Weight-bearing after Operation	Osseous Union (X-ray)	Function	Comment
16	53 F.		May 11, 1935	May 22, 1935 (11 days)	3 months	Yes	Poor	Coxa vara and *osteo-arthritis* due to softening of neck and head, January, 1937
17	57 F.		Aug. 1, 1935	Aug. 9, 1935 (8 days)	2 months	Yes	Good	Nov. 18, 1936, walking well. Died August, 1937, cerebral hæmorrhage
18	81 F.		July 23, 1935	Aug. 1, 1935 (9 days)	6 weeks	Yes	Good	May 1, 1938: walking well—no pain 3 years later
19	52 M.		Aug. 9, 1935	Aug. 14, 1935 (5 days)	6 weeks	Yes	Normal	Aug. 1, 1936: working
20	52 F.		Aug. 12, 1935	Aug. 21, 1935 (9 days)	8 weeks	Yes	Normal	Walks without stick, June, 1937
21	81 F.		Aug. 14, 1935	Aug. 27, 1935 (13 days)	3 months	Yes	Good	Walks well, Nov. 24, 1936. Died, 1938
22	68 F.		Sept. 9, 1935	Sept. 13, 1935 (4 days)	3 months	Yes	Normal	September, 1937: walks 3 miles
23	80 F.	Urinary incontinence	Sept. 14, 1935	Sept. 26, 1935 (12 days)	—	—	—	Death 3 weeks after operation—pneumonia
24	82 F.	Chronic uræmia	Sept. 20, 1935	Oct. 3, 1935 (13 days)	—	—	—	Death—uræmia and dropsy 2 months after leaving hospital
25	77 F.		Sept. 30, 1935	Oct. 9, 1935, (9 days)	3 months	Yes	Fair	"Walks any distance", Sept. 17, 1937, but May 2, 1938, walking only ½ mile—*osteo-arthritis* present—no pain, only stiffness
26	65 F.	Paget's disease and osteo-arthritis of knee	Oct. 20, 1935	Nov 6, 1935 (17 days)	?	Yes	Poor	Has old arthritis. X-ray, Aug. 1, 1938, osseous union—*osteo-arthritis*
27	67 F.		Oct. 28, 1935	Nov. 13, 1935 (16 days)	6 weeks	Yes	Good	1937, examined
28	53 F.		Dec. 15, 1935	Dec. 24, 1935 (9 days)	6 weeks	Yes	Normal	Nov. 15, 1937: "walks miles daily"
29	64 F.		Dec. 25, 1935	Jan. 2, 1936 (8 days)	1 year	Yes	Fair	Second operation for delayed union nail and graft, July 8, 1936. May, 1938, walks 1½ miles—little pain
30	60 F.		(About 1 week)	Feb. 26, 1936	2 months	Yes	Normal	Aug. 22, 1937: walking without limp
31	70 F.	Cardiac failure	March 12, 1936	March 26, 1936 (2 weeks)	6 months	Yes	Fair	Second operation, April 3, 1936. Walking with an occasional ache, March 1, 1938. Slight *osteo-arthritis*
32	80 F.	Weight, 18 st.	March 31, 1936	April 8, 1936 (8 days)	3 months	Yes	Poor	Second operation, slipped nail, June 3, 1936. Nov. 30, 1937: walking 1 mile

								March 1, 1938. Slight *osteo-arthritis*
32	80 F.	Weight, 18 st.	March 31, 1936	April 8, 1936 (8 days)	3 months	Yes	Poor	Second operation, slipped nail, June 3, 1936. Nov. 30, 1937: walking 1 mile until 2 weeks before—*necrosis of caput*. Died April, 1938
33	68 M.		April 11, 1936	April 15, 1936 (4 days)	6 weeks	Yes	Fair	*Osteo-arthritis* beginning April, 1938
34	52 F.	Cardiac failure	March 29, 1936	April 16, 1936 (18 days)	5 months	Yes	Good	June 20, 1938: walks 6 miles. Occasional ache. X-ray shows early *osteo-arthritis*
35	76 M.		April 3, 1936	April 22, 1936 (3 weeks)	?	?	Fair	Sept. 9, 1937: "Rheumatism in cold weather". Letter, May 1, 1938: pain—*osteo-arthritis*? Not examined
36	75 F.	Bronchopneumonia	May 25, 1936	June 4, 1936 (10 days)	4 months	Yes	Good	Died, carcinoma colon, April 24, 1937
37	70 F.	Rheumatoid arthritis —gastric ulcer	June 16, 1936	June 3, 1936 (18 days)	About 9 months	?	Bad	Walked with crutches—then myocardial failure—bed-ridden July 26, 1938—no shortening. X-ray: ? osseous union
35	65 F.	Nephritis—poor risk	June 16, 1936	June 23, 1936 (1 week)	—	—	—	Death 24 hours after operation—uræmia
39	70 F.		June 4, 1936	June 15, 1936 (11 days)	3 months	Yes	Good	X-ray Oct. 11, 1937—early *osteo-arthritis*—slight pain
40	73 F.	Acute cholecystitis	July 16, 1936	Aug. 5, 1936 (20 days)	3 months	Yes	Normal	Sept. 30, 1937: walks as well as ever—slight changes in *caput femoris*
41	84 F.	Feeble—poor risk	Aug. 10, 1936	Aug. 18, 1936 (8 days)	—	—	—	Death, Aug. 22, 1936—senility
42	73 F.		Sept. 29, 1936	Oct. 9, 1936 (10 days)	6 months	Yes	Good	Slipped nail; second operation, nail and graft, Nov. 10, 1936. Painless walking June 6, 1938
43	98 F.	Incontinence	Oct. 24, 1936	Nov. 4, 1936 (10 days)	6 months	?	Poor	Aug. 1, 1938: walks with aid of chair about house; no pain or shortening; no X-ray
44	63 F.	Shock	Nov. 6, 1936	Nov. 14, 1936 (8 days)	3 months	Yes	Normal	June, 1938: dances
45	72 F.		Nov. 11, 1936	Nov. 18, 1936 (7 days)	8 months	Yes	Fair	Nail re-inserted at 3 months. Walking—no pain, May 2, 1938
46	58 F.	Diabetes	Dec. 24, 1936	Dec. 30, 1936 (6 days)	—	—	—	Death, Jan. 7, 1937
47	64 F.	Weight, 16 st.	Feb. 21, 1937	Feb. 24, 1937 (3 days)	5 months	Yes	Good	May 1, 1938
48	70 F.		April 7, 1937	April 14, 1937 (7 days)	—	—	—	Death April 24, 1937—infected wound
49	73 F.		June 9, 1937	June 15, 1937 (6 days)	3 months	Yes	Good	June 14, 1938: walking well
50	70 F.		July 7, 1937	July 14, 1937 (7 days)	8 months	Yes	Normal	Examined, July 20, 1938

shortens; coxa vara develops; but whatever changes occur, they all fall into the group discussed in this section. In the present series this disappointing condition has developed in at least one-third of those cases with osseous union, or 25 per cent of all operated cases. It usually developed towards the end of the first year, but sometimes not until after two to three years. Apparently, therefore, this degeneration may occur at any time, perhaps years later. I cannot understand how other surgeons find it rarely. The pain and degenerative changes invariably progressed, and are to be observed from month to month. A patient might be walking well, with no pain; then occasional pain, especially after long walks; then he uses one stick; then two sticks, and eventually crutches; and finally he is almost unable to walk at all because of the pain. The results fell into three groups: (1) Those whose disablement due to pain on walking equalled that of non-union—3 cases. (2) The commonest group—those with slight to moderate, but bearable, pain, who are much better off than with non-union. The X-ray appearances, despite the fair function, may show gross degeneration—8 cases. (3) Those with slight stiffness and no pain, except perhaps with changes of the weather, but with very definite X-ray appearances of degeneration (*Case* 34)—3 cases. These may have trouble later.

A precaution against osteo-arthritis developing during the first year is to avoid weight-bearing for a few weeks whenever walking is followed by pain, especially if X-ray examination discloses suspicious areas of rarefaction or sclerosis in the caput femoris. *Pain is always the danger signal.* In my own cases true massive necrosis ('absorption' as in *Figs.* 505–508) of the head is rare, but secondary degenerative arthritis associated with irregularity of the caput femoris occurred—as stated—in about one-third of all cases of osseous union. This figure will certainly increase with time. Other surgeons will report about that as the years pass.

That secondary degenerative changes would follow osteosynthesis, or indeed any other method, could be predicted with certainty, because it is well known that any injury or disease involving a weight-bearing joint surface is very liable to result in these changes. A third-degree Pott's fracture often ends in a severe degeneration of the ankle-joint, and a fracture of the os calcis may cause a painful arthritis in the subastragaloid joint, especially if we permit weight-bearing even in a walking cast under three to six months. We could not hope that the hip-joint would be an exception to this rule. It is for this reason that an authority like E. W. Hey Groves has repeatedly urged that late results should be brought forward, and stimulated by his suggestion I have ventured to submit this commentary on my own experiences.

II.—UNUNITED FRACTURES (OVER THREE WEEKS OLD)—30 CASES

A.—A study of 14 ununited fractures (up to three months old) treated by extra-articular osteosynthesis with a Smith-Petersen nail only, examined at least one year after operation, gave the following results:—

Non-union	2 (14·3 per cent)
Osseous union (X-ray)	9 (64·3 per cent)
Death after operation	0
Death in first year (before union known)	3 (21·4 per cent)
Total	14

Comment.—Osseous union was obtained in 64·3 per cent of all cases, but if deaths in the first year are excluded, osseous union equalled nearly 82 per cent. Head necrosis and osteo-arthritis after osseous union developed after one year in 4 cases (29 per cent). Therefore nearly half of those with osseous union developed osteo-arthritis (severe form).

B.—A study of 16 old and ununited fractures (up to nearly two years old) treated by extra-articular osteosynthesis with a Smith-Petersen nail and whole-thickness fibular bone-peg (suggested by Leo Doyle; technique based on M. S. Henderson's), examined at least one year after operation, showed results as follows :—

Non-union	5 (31·25 per cent)
Osseous union	11 (68·75 per cent)
Death or result unknown	0
Total	16

Comment.—Osseous union occurred in 68·75 per cent of cases; head necrosis and osteo-arthritis after osseous union developed in 4 cases (25 per cent). Therefore nearly one-third of the patients with osseous union developed osteo-arthritis later (moderate form).

Figs. 510, 511 *Figs.* 512, 513

FIGS. 510, 511.—*Case* 5, *Table III* (*see Figs.* 499–504). Radiograph taken Sept. 1, 1936, immediately after operation. Smith-Petersen nail in lower third of neck, and fibular peg in upper third. Note pseudarthrosis and gap between head and neck, especially in the upper and posterior quadrants, where osseous union is always slow.

FIGS. 512, 513.—*Case* 5. The appearance on March 8, 1938. Smith-Petersen nail removed and osseous union undoubtedly present, with trabeculations across the old pseudarthrotic site. The caput femoris is normal; good joint space; function almost normal. No immobilization after operation, but no weight-bearing was allowed for 6 months.

A three-weeks old fracture has been arbitrarily called old and ununited because after four weeks undoubted shortening of the neck can be sometimes observed. Therefore after three weeks it can be assumed that the caput femoris detached from its blood-supply has less chance of osseous union, and that secondary degenerative changes are more probable than if operation were performed earlier. Up to three months there may be little fibrous tissue between the fractured surfaces; then a pseudarthrosis with fibrous bands between the two fragments; and finally a "nearthrosis" with sclerosed fracture surfaces covered with cartilage (*Fig.* 503).

As an abstract proposition, the ideal treatment for ununited fractures is the complete anatomical restoration of the neck and head of the femur. In selected

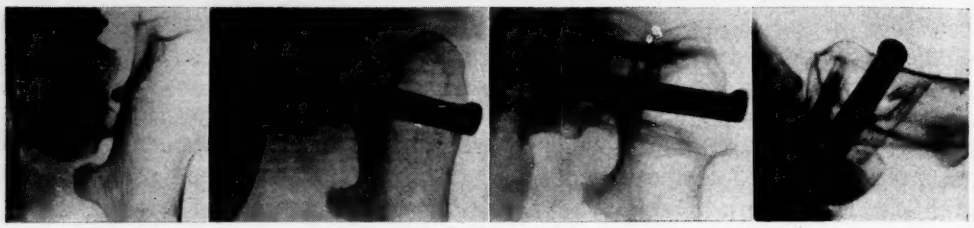


Fig. 514 *Fig.* 515 *Fig.* 516 *Fig.* 517

FIG. 514.—*Case* 2, *Table III* (aged 73). Radiograph on Sept. 3, 1935, nearly 2 years after fracture; caput femoris is well preserved.

FIG. 515.—Same case. Radiograph taken Sept. 10, 1935, at operation before President (E. W. Hey Groves) and members of orthopædic section, B.M.A. meeting, Melbourne, 1935. A long nail deliberately driven into caput femoris centrally into free cavity of acetabulum; no limitation of movement or pain thereby (*see Figs.* 520, 521).

FIG. 516.—Same case. Radiograph taken Dec. 11, 1935. Union not progressing, so a split fibular graft above and below central nail was inserted.

FIG. 517.—Same case. Radiograph taken Dec. 11, 1935. Lateral view; neck lying in front of caput.

Fig. 518 *Fig.* 519 *Fig.* 520 *Fig.* 521

FIG. 518.—*Case* 2 (same as *Figs.* 514–517). Radiograph taken April 24, 1937. Nail removed and undoubted osseous union; normal head; walks without stick; occasional aching (April, 1938).

FIG. 519.—Same case. Radiograph taken April 24, 1937. Lateral view shows sound osseous union, although the external rotation was not fully corrected.

FIGS. 520, 521.—Same case. Full range of hip and knee movements. The same range existed before removal of nail, which can project half an inch into centre of hip-joint and cause no trouble if central in the caput. Such a good result is so occasional that osteotomy for a fracture over 3 months old is better; unfortunately most patients over 60 are unsuitable for osteotomy.

cases this can be secured by a combined extra-articular osteosynthesis with the Smith-Petersen nail and fibular graft; Leo Doyle suggested this to me. Delbet's school used the graft plus a screw in 1924, but thought the results were worse then with the graft alone—their screws no doubt were not made of stainless steel. The nail ensures fixation without the need of the large plaster-of-Paris apparatus, whilst the fibular graft promotes osseous union. Thereby a reasonably certain method of success is combined with an operation almost without any immediate danger. In 42 (30 reported here) operated ununited fractures there were 2 deaths, which of course is very different from the high mortality in recent fractures.

Naturally the prospect of obtaining osseous union in old ununited fractures is confronted with difficulties which are unfortunately greater than in recent fractures. Nevertheless the problem of non-union in fractures of the femoral neck must be faced, because they occur even in children (*Figs.* 499–504 and *Figs.* 510–513) and in healthy adults, as well as in the decrepit. Common to both recent and old fractures is the defective blood-supply to the caput femoris following the fracture. In addition there are the following rather serious difficulties in the old ununited fractures: (1) Poor general condition; (2) Changes in the caput femoris; (3) Intervention of fibrous tissue or nearthrotic formation.

1. Poor General Condition.—If the immediate mortality of a recent fracture is about 25 per cent, then those who survive and become cases of old ununited fractures can be assumed to be constitutionally strong; especially if the fracture when recent and painful was treated in sandbags, etc., which is always an exhausting method of treatment. The still popular traction method is useful as a temporary measure, but, though less strain on the constitution than the sand-bag method, practically never results in osseous union. It can only separate the fractured surfaces; it does not control rotation, and if the fracture line is oblique or vertical, it exerts a shearing force which bends and twists the callus—thus the beneficial effect of pressure on osseous union obtained by nailing or by the Whitman plaster apparatus is absent. Unfortunately it is still a favoured method, although most text-books no longer describe it for this fracture. Lange reported very bad results by the traction scheme. Until ten years ago the traction method was generally used in Germany, and results were poor. Hübner in 1923 studied the end-results of 135 medial fractures treated by traction: only 6 per cent healed with osseous union. The good results claimed by the most optimistic for the traction method are from 10 to 15 per cent. It seems more than a coincidence that these figures correspond exactly with the frequency of the occurrence of impacted fractures, which almost invariably unite no matter what we do. Although the treatment of this fracture was enormously advanced by Whitman's insistence on reduction and immobilization in a cast, the latter often failed to prevent recurrence of the deformity. The spica does not provide perfect immobilization, and, as Watson-Jones has pointed out, external rotation between the fractured surfaces can take place, as is well shown in *Fig.* 502.

Whatever may have been the general condition of the patient at the time of the original accident which caused the fracture, it has often deteriorated when the question of operative treatment for non-union arises. Then operation is often refused to the elderly patient, especially when the operative procedure contemplated is a long and difficult one involving arthrotomy. So true is this that Melvin Henderson, reporting 631 cases (all old cases except 51 recent fractures) from the Mayo Clinic, stated that only 113 were eventually operated upon. Some patients themselves declined when the risk of operation was pointed out.

With the exception of extra-articular osteosynthesis, the only relatively safe procedure is a high Schanz or Lorenz osteotomy, both of which are palliative, and must be inferior, in theory at least, to the ideal procedure, i.e., union of the neck and head of the femur, thereby restoring the normal anatomical form. The Lorenz osteotomy causes further shortening. The danger of femoral thrombosis after osteotomy is real in old people. Following the osteotomy a necessary requisite is the immobilization of the hip-joint and limb, as well as the patient as a whole.

This introduces the ever-present danger of decubitus in the elderly, especially when a large plaster spica is applied. If this form of immobilization is always considered absolutely necessary by the surgeon, then many patients must be denied the osteotomy. Actually, following the osteotomy one need not immobilize the limb in a spica, but merely rest it on a pillow; outward rotation of the limb is prevented by suspending the foot with adhesive strapping and spreader and cord to an overhead beam. Nearly forty osteotomies for various hip conditions, including ununited fractures, have been treated by this method, and bony union at the site of osteotomy has always resulted in three months (paper to be published later). Control X-ray examinations weekly for four weeks are essential, so that any derangement of the fragments can be adjusted by manipulation, which is very seldom necessary. However, this present report deals with extra-articular osteosynthesis, and its object is to present evidence of its suitability or not for old fractures. It is strange that Böhler, Lange, and other Continental surgeons who have used osteotomy for years following the Schanz school, and his pupil Pauwels, should have abandoned, at least for the time being, osteotomy for osteosynthesis. Both methods have their place; it remains to be seen whether osteotomy is the only suitable method. There is a very small place for the various dangerous intra-articular methods, because, with few exceptions, the results are so problematical that they do not justify the risks entailed.

2. Changes in the Caput Femoris.—The two problems are: (*a*) Is the caput femoris viable? (*b*) If it is alive, is it worth while attempting osteosynthesis, because even if osseous union is obtained, necrosis of the head may follow in part or in whole, or deformation resulting in secondary traumatic osteo-arthritis?

In regard to the first question there is no doubt that it is often alive despite a fracture many months old. On one occasion when performing arthrotomy for non-union, an operation I have now abandoned, I actually saw the fractured surface of the head bleed as it was being freshened with the chisel. No doubt the fibrous tissue bridge between the head and neck and the capsular adhesions carried into the head new blood-vessels. The head in these cases, although it is alive, is always denser than the normal head. On driving in the nail there is marked contrast between the softness of the neck due to hyperæmia and the somewhat sclerotic head, which has been caused by the diminished, though often adequate, blood-supply. The absolutely devascularized head in the X-ray pictures appears characteristically 'white' and dense in contrast with the surrounding atrophied bones. Even in this case some authorities have considered that bone union can be obtained and is worth trying for, as regeneration can occur; but, as Watson-Jones points out, such bone must be deprived of its cartilaginous covering and osteo-arthritis must almost inevitably follow. In other cases the density of the head of the femur in the X-ray films is the same as the neck and surrounding pelvic bones. The convex outline of the caput is unaltered and the joint space is not narrowed. Then the head is certainly alive, and is deriving its blood-supply from the vessels in the adherent capsule, synovial membrane, and newly formed fibrous tissue between the head and neck. No doubt in many cases the old ununited caput derives a better blood-supply when the fracture surface is rotated forward and is in contact with vascular synovial membrane, than when the recent fracture is perfectly reduced, when it must derive its blood-supply from its contact with the fractured surface of the neck, i.e., a new endosteal blood-supply.

The second question is very important, because if a painful osteo-arthritis develops after the osseous union, then the disability is sometimes as severe as that following non-union. In the common mon-articular osteo-arthritis of the hip-joint a history of trauma can often be obtained. Therefore it is only to be expected that it will not infrequently follow a fracture of the neck of the femur. The self-impacted abduction or coxa valga fracture is sometimes followed by the severest head necrosis or deformity and subsequent osteo-arthritis, even though no weight-bearing has been permitted for months.

The suggestion that all ununited fractures of the femoral neck—that is, after about three weeks—are unsuitable for osteosynthesis because osteo-arthritis is inevitable, and are only suitable for a trochanteric osteotomy, however, requires consideration. The Lorenz type of osteotomy has been warmly sponsored by McMurray as the standard method of treatment for ununited fractures. Nevertheless, despite some good functional results with the osteotomy in patients under 60 years of age, the restoration of the head and neck by osteosynthesis in the abstract is preferable. It is true that a deforming osteo-arthritis may develop later, but it is not inevitable. Therefore we are justified in performing osteosynthesis in selected cases. If the caput femoris shows perfect conformation and the neck is of reasonable length and not completely absorbed down to the trochanteric region, then theoretically the ideal is to restore the former anatomical arrangement. If our efforts are followed by osseous union, and this is not followed by secondary deformity of the head later, even in a proportion of cases, then the method has a definite place because it is a less distressing method than osteomy. The problem then is the selection of suitable cases (*see* CONCLUSION).

3. Intervention of Fibrous Tissue or Formation of a Pseudo-arthrosis.—This occurrence is no doubt common, especially if weight-bearing has driven the lower fragment up on to the ilium behind the acetabulum, as in the worst cases. More often the neck is looking forward and lying in front of the head. Often any union, whether fibrous or nearthrotic, is between the back parts of the head and neck. It is for this reason that the neck is absorbed on the posterior aspect more than the front (*Figs.* 502, 511). Also, of course, the back of the neck is usually crushed by the original injury. The most favourable cases for osteosynthesis are those that have been treated unsuccessfully for some months by either the Whitman or continuous traction methods, because then displacement is minimal. Another favourable type is the individual who has never walked since the accident. In all of these we can usually bring the fractured surfaces opposite one another without arthrotomy, which I believe is always unjustifiable because it is too dangerous.

After the neck has become decalcified by the hyperæmia, the fibrous and sharp end of the neck may have torn through the synovial membrane and capsule in the front of the hip-joint, involving even the Y-shaped ligament. Then a large collagenous matrix which then represents the remains of the osseous neck is a potent source of fibrous intervention between the fragments. In addition, the amount of adherent fibrous tissue can be assumed. Fibrous tissue between the fragments is of course a great obstacle to the success of extra-articular osteosynthesis. It not only prejudices osseous union, but always hinders and sometimes even prohibits, accurate reduction. Nevertheless reduction can be obtained by extra-articular osteosynthesis, even up to two years, and perhaps later, after the injury in selected cases, but whether it is worth doing is a different matter. Since

osseous union sometimes follows either the Lorenz or the Pauwels-Schanz type of osteotomy even after months, when there must be abundant fibrous tissue intervening, then we should not be dissuaded from osteosynthesis for this reason alone.

Conditions for Extra-articular Osteosynthesis.—The following conditions should be considered before extra-articular osteosynthesis is justified :—

1. *The Patient.*—The strong desire of the injured person for some relief, but the general condition must be good and the prospects of longevity reasonable.

2. *Reduction must be Possible.*—The reduction must be gradually obtained before operation by a preliminary period of traction for two to three weeks. Lateral X-ray examination is always essential because the neck is often lying in front of the head, and this is the main deformity which we wish to overcome, although in the single frontal view the position appears satisfactory. If the reduction cannot be obtained, or rather if the preliminary traction has not altered the position of the fragment the slightest, then a further period of traction would be futile. Trochanteric osteotomy should then be performed.

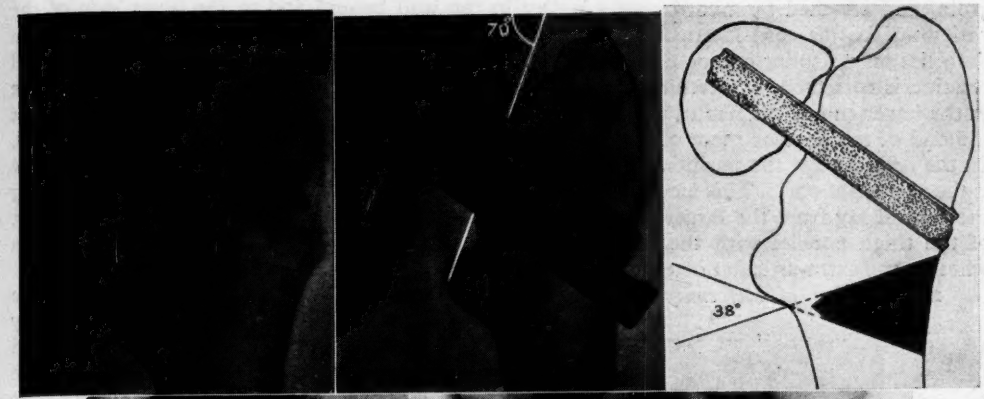
3. *The Caput Femoris must be Alive.*—The head can be considered avascular when the X-ray appearances show a relative density compared with the neck fragment and the pelvic bones, whilst a well-vascularized caput femoris shows no difference in density. Then the blood-supply has been obtained through fibrous tissue, synovial membrane, and capsule attached to the head, which has been a good friend because it carried into the head a good blood-supply. Unfortunately this fibrous tissue may also be an enemy to both reduction and subsequent osseous formation. Unless the caput femoris shows a perfectly circular and uneroded outline, the cartilaginous surface is affected. Osteo-arthritis is then inevitable. In older cases the head is necrosed and of course beyond repair. Osteosynthesis is contra-indicated in both cases. High trochanteric osteotomy is the treatment of choice.

4. *The Neck must not be too Short due to 'Absorption'.*—After a month the neck is always shortened more or less, but for a longer and variable time it may still be of sufficient length to permit osteosynthesis. The tip of the great trochanter with its muscular attachments should not approximate too closely to the upper rim of the acetabulum. Furthermore, when the neck is much absorbed, there is always a proportionate increase in the fibrous tissue which represents the fibrous matrix of the decalcified bone formerly constituting the neck. About one inch at least of neck must remain.

The anteroposterior X-ray picture should be made with the limb strongly internally rotated so that the full length of the neck can be displayed, as with external rotation the neck is foreshortened. The lateral view shows the full length of the neck, and also the main displacement, or rather the one which is most difficult to correct, i.e., the neck lying in front of the head.

5. *Despite Good Reduction and Osteosynthesis a Gap Exists between the Fracture Surfaces.*—The gap may disappear (*Figs.* 510–513), but unfortunately it may not. Therefore I now in these cases reduce the fracture, insert a central bone-peg, and then perform the wedge-removal osteotomy (Pauwels). When the osteotomy has healed, weight-bearing tends to press the head and neck together, thereby ossifying the fibrous tissue which intervenes, especially in the presence of the bone-peg. *Figs.* 522–526 illustrate this procedure, except that the Smith-Petersen nail there illustrated I no longer use in such a case.

Fig. 522 *Fig.* 523 *Fig.* 524



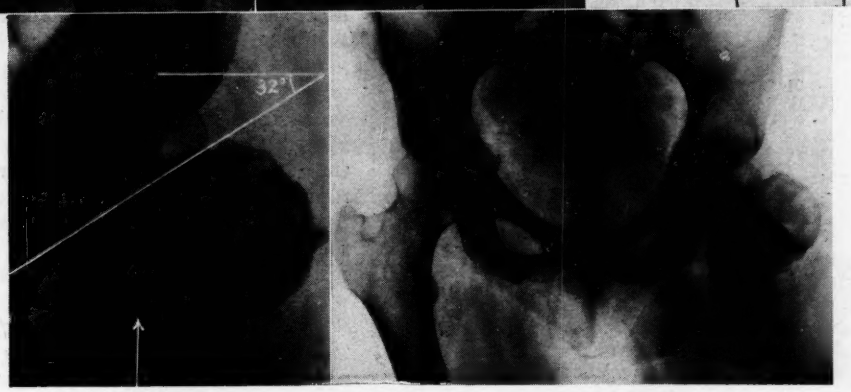


Fig. 525 *Fig.* 526

FIG. 522.—*Case* 14, *Table III* (aged 47). Radiograph taken April 13, 1937, nearly 18 months after failure by traction; then intra-articular osteosynthesis with a short nail with no head, inserted horizontally almost, through the soft trochanter instead of in the shaft of the femur, ½ in. distal to the trochanteric tubercle. Note deformed head and loss of neck.

FIG. 523.—Same case. Radiograph taken April 21, 1937. Extra-articular osteosynthesis with long oblique nail in lower part of neck and fibular graft in upper part. Nail deliberately driven through head. Fracture line is 70° (*Group III* fracture).

FIG. 524.—Same case. Radiograph taken Sept. 30, 1937. Plan of wedge osteotomy to convert *Group III* into *Group II* fracture. Nail has been removed in order to allow apex of wedge to point to small trochanter. In order to lock the fragments, the osteotomy is incomplete at the apex so that the bridge can be bent or broken.

FIG. 525.—Same case. Radiograph taken Feb. 5, 1938, 3 months after removal of 38° wedge and closure of gap by abduction. Upper fragment now strongly adducted and fracture line 32° to horizontal on weight-bearing. A shearing force has now been converted into a pressure force. Note the regenerated caput femoris and normal joint line and space between the head and acetabulum margin.

FIG. 526.—Same case. Radiograph taken May 11, 1938. Walking painlessly with only the slightest limp and one stick, after being a cripple for nearly 2 years. Note the well-vascularized head, which has enlarged and is regular in contour. The adduction of the upper fragment has compensated for the shortening due to the 'absorbed' neck.

The same result may have followed the osteotomy alone, although the preliminary osteosynthesis corrected a shortening of over 2 in., and, by opposing the two fractured surfaces, promoted osseous union when weight-bearing, after reclination of the fracture line by the osteotomy, caused a pressure instead of shearing force on the fractured surfaces.

Technique of Extra-articular Osteosynthesis.—The technique may be considered under the following headings: (1) Preliminary traction; (2) Reduction of deformity; (3) Determination of neck-shaft angle and site on femur for drilling in wires; (4) Insertion of guide wires; (5) Cutting of fibular peg; (6) Insertion of the canalized Smith-Petersen nail and fibular peg.

1. *Preliminary Traction.*—Much greater weight is required than in recent cases, where over 8 lb. is harmful because it stretches the capsule and may prevent a correct reduction. A weight of 30 lb. is applied to the affected limb through skeletal traction from the lower end of the femur. If there is much adductor shortening, the adductors should be cut. The foot

of the bed should not be elevated. A sling (well padded) should be placed around the affected groin, and attached by a cord over a pulley in the wall behind and to the outer side of the patient. To this cord is attached 20–30 lb., and thereby lateral traction is obtained. The limb lies on no splint except a large pillow in a moderately abducted position. The external rotation is corrected by attaching a cord from the outer end of the stirrup for the pin or wire in the lower end of the femur, to a weight of about 2 lb. suspended over a vertical pulley. At the end of ten days or more of such powerful traction, a control X-ray examination is made. In the frontal view the position of the fragments may appear satisfactory, but the lateral view is the important one. This view is obtained very simply by flexing the good thigh and directing the central ray from the target into the perineum, the casette being held on the outer aspect of the thigh parallel with the femoral neck. As a rule the lateral examination determines whether the extra-articular osteosynthesis is feasible.

2. *Reduction of Deformity.*—The patient is placed on the orthopædic table and the deformity remaining after the preliminary traction corrected, especially the forward displacement of the neck. Hence the latter should be firmly pressed back whilst the limb is being internally rotated. This manœuvre is greatly facilitated by lateral traction with a sling around the groin, as recommended so strongly by the French surgeons. In order to overcome the shortening, very powerful screw traction is necessary. In recent fractures, of course, practically no force is necessary to do this. Frontal and lateral X-ray pictures are now made, and if satisfactory we can proceed.

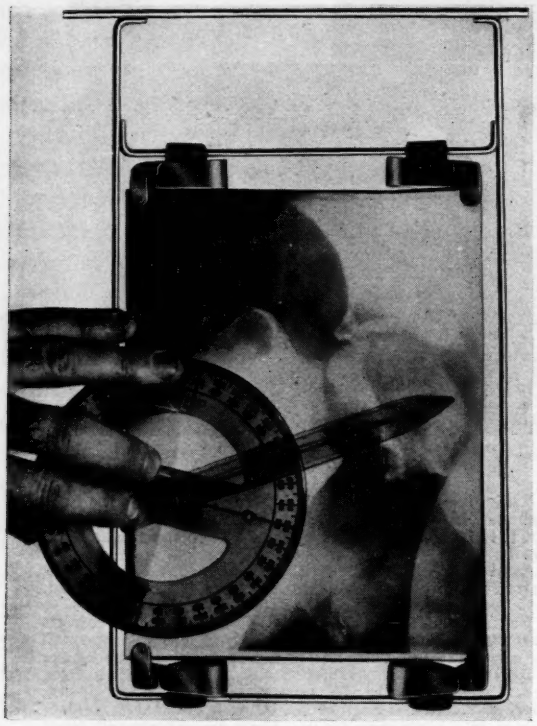


FIG. 527.—*Case* 3, *Table III.* June 24, 1936. Extra-articular osteosynthesis; control X-ray picture after reduction on orthopædic table; neck-shaft angle is measured one finger's breadth distal to trochanteric tubercle (*see Fig.* 528).

3. *Determination of Neck-shaft Angle and Site on Femur for Drilling in Wires.*—The wet film of the frontal view (*Fig.* 527) is studied, and invariably we see a small spur or eminence at the most distal part of the roughened external aspect of the great trochanter (*Fig.* 528). This slightly overhangs the subtrochanteric fossa, and may be called the trochanteric tubercle—it is always a well-recognized landmark to surgeons familiar with this operation (Tuberculum innominatum—Felsenreich). About one finger's breadth distal to the trochanteric tubercle a scratch is made on the wet film. This mark is opposite the lesser trochanter, and must be made lower than this when a Smith-Petersen nail is used alone, without an accompanying graft. The celluloid transparent protractor is placed with its centre point against the exact outer edge of the femoral shaft opposite the scratch mark. The base line of the protractor is placed very accurately (because this method measures the angle very precisely) against the outer edge of the femoral shaft, which is practically a straight line. The pointer of the protractor is now swung so that it points through the centre of the caput femoris or very little below it (because room must be left for the fibular transplant). The angle is read off, and varies usually from 120° to 135°. In addition to using this method for the old fractures, I now use it in recent cases. It is accurate to within from 1° to 3°. Complicated directing apparatus is absolutely unnecessary.

4. *Insertion of Guide Wires.*—A 4-in. lateral incision over the upper end of the femur is made. It extends proximally to the tip of the great trochanter. The aponeurosis of the tensor fasciæ femoris muscle is incised longitudinally; the index finger can palpate the apex of the subtrochanteric fossa by slipping it along the vastus externus covering the smooth surface

of the lateral aspect of the femur. The small spur of trochanteric tubercle is palpated and the aponeurosis of the vastus externus incised at this spot and then continued distally along the femur. This significant landmark corresponds also to the highest linear attachment of the vastus externus, and the highest aponeurotic fibres of origin are an important guide to its whereabouts if there is any doubt.

If the mark on the X-ray film was one finger's breadth distal to the subtrochanteric tubercle a small drill hole is made at the corresponding point on the lateral aspect of the femur. A second hole is made ¼ in. proximal to the first mark, and yet another, ¼ in. distal to the first one. The object of the marks is to allow the Kirschner wires to engage the bone without slipping in front or behind the smooth dense convexity of the lateral aspect of the femur on drilling. It is a presumption to rely on inserting one wire only; moreover, the use of more than one wire anchors the head and prevents it rotating on driving in the nail along the correct guide wire.

The forward or backward declination of the femoral neck can be determined as follows: A Kirschner wire is thrust along the front of the neck of the femur, naturally at the predetermined

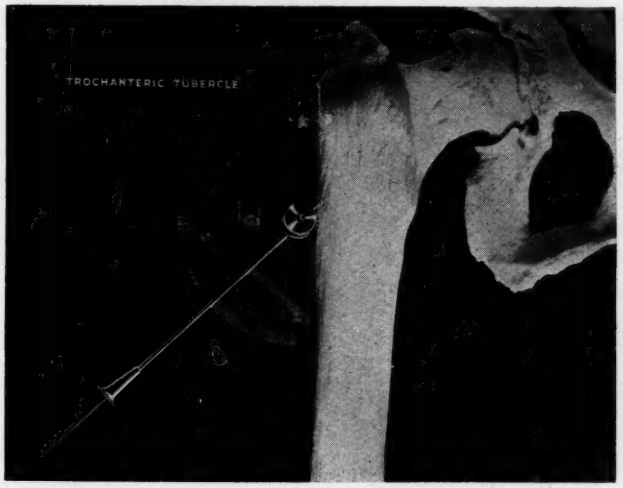


FIG. 528.—Compare this with *Fig.* 527, where the neck-shaft angle is measured on the wet film after reduction. The metal protractor (and cannula for the Kirschner wire) is placed with its centre point one-finger's breadth distal to the trochanteric tubercle with the cannula set at the estimated angle. This is a very accurate method, within 1° or 2°.

neck-shaft angle (say 135°). This wire now indicates approximately the angle of the neck to the horizontal plane (with the patient lying horizontally). The cannulated protractor (*Fig.* 528) is set at the correct neck-shaft angle (say 135°) and is held firmly against the femur. If the declination angle of the neck is horizontal, then the protractor is held horizontally. In most cases a wire which transfixes the true central axis of the neck and is parallel with a wire lying on the front of the neck, will then pass into the anterior quadrant of the caput because the head is usually retroverted and lying behind the neck, due to absorption of bone in the back of the neck. This is a bad place for the nail, which should be central or in the posterior quadrant. At any rate it is easy to calculate fairly accurately the direction of a wire which should impale the centre of the caput in the lateral projection. If a ruler is laid along the front of the neck in the lateral X-ray picture, it will correspond with the wire in front of the femoral neck in the patient. No angle-measuring instrument is required to enable the surgeon to calculate the angle between this line and that made by the line which will guide a wire into the centre of the caput approximately. With experience, the surgeon's eye can judge the angle sufficiently accurately, especially as we shall have the choice of three wires. A Kirschner wire is drilled along the cannula for a distance of 3½ in. When using a fast electric drill the density of the caput is readily appreciated. A second wire is drilled into the head at a slightly different angle in the lateral plane only ¼ in. proximal to the first wire. A third wire is

drilled into the caput ¼ in. distal to the first wire, also at slightly different angles, on the lateral plane. A large sterile sheet is thrown over the operation area and the control X-ray examination made.

5. *Cutting of Fibular Peg.*—Whilst the X-ray films are being developed a fibular transplant—about 3¼ in. in length—is removed from the middle third of the leg on the same side. The bone is exposed between the peroneii and soleus muscles, and muscle and periosteum are scraped off. One end is rather bluntly pointed, and several ⅛-in. holes are drilled in it at intervals. Then the X-ray films of the wire guides are studied. The anteroposterior view always shows that one or other wire is in the correct position. Rarely, as a result of the lateral X-ray view, another attempt must be made.

6. *Insertion of the Canalized Smith-Petersen Nail and Fibular Peg.*—The length of the nail is estimated by subtracting the length of wire projecting from the femur from that in the

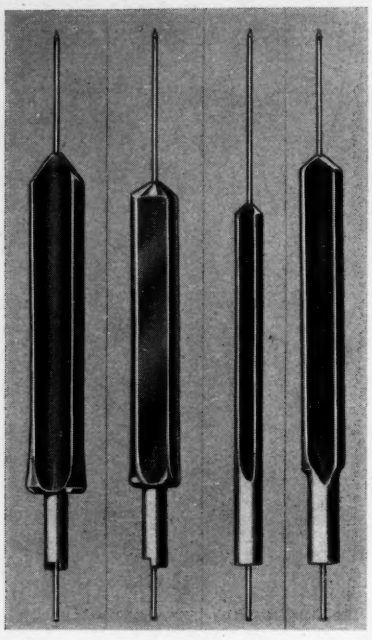


Fig. 529

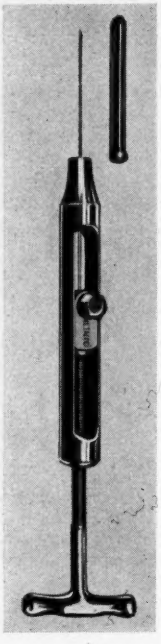


Fig. 530

FIG. 529.—Drills for electric or hand machines canalized for Kirschner guide wires (first suggested by M. S. Henderson) for insertion of fibular graft into neck and head of femur.
FIG. 530.—Wire extractor for withdrawing bent wires, made after Felsenreich's model—a valuable instrument.

bone. A 3½-in. nail is generally the correct length. As soon as the nail has been driven into the head it only takes five minutes more to insert the bone-peg. A Kirschner wire is pushed along the canal in the metal nail and the projecting end of the wire is used as a sight for another wire which is drilled into the bone about half an inch proximal to it, so that the fibular graft will be only ⅛ in. proximal to the nail, i.e., almost touching the head of the nail. Both wires should be almost exactly parallel in both planes. Then a canalized drill (*Fig.* 529), as recommended first by Melvin S. Henderson, is threaded over the wire, proximal to the nail, and drilled into the neck for 2 in. This canalized drill is also very useful for making the hole in the lateral aspect of the femur, recommended by Watson-Jones, which prevents splitting of the femoral shaft, when nailing recent lateral or extracapsular fractures. It would not be possible to drill a hole otherwise as the guide wire would prevent it. I now think many lateral fractures are better treated by the Smith-Petersen nail than by troublesome plaster or traction methods. The wire is now removed and the drill is reinserted until the hole is 3 in. deep. As the drill penetrates deeper, it is removed from time to time and the

Table II.—Details of 14 Cases of Extra-articular Osteosynthesis with the Smith-Petersen Nail only for Old (over 3 weeks) Medial Fractures

Case No.	Age and Sex	Pre-operative Complication	Date of Fracture	Date of Operation	Weight-bearing after Operation	Osseous Union (X-ray)	Function	Comment
1	66 M.		Sept. 10, 1933	Oct. 10, 1933 (4 weeks)	1 month	Yes	Fair	Gross *osteo-arthritis*, February, 1937 (nail into rim of acetabulum)
2	79 F.	Urinary incontinence	About 5 months old	Jan. 9, 1935	—	?	Never walked	No X-ray before death 5 months after operation
3	68 F.	Bronchiectasis — poor risk	Jan. 19, 1935	March 8, 1935 (7 weeks)	—	No	—	Very atrophic bone—nail loosened, second operation failure—death 5 months later
4	71 F.		Feb. 23, 1935	March 15, 1935 (21 days)	6 weeks	Yes	Improving	Walked well 12 months; then Lorenz osteotomy for severe *osteo-arthritis*—improving, June, 1938
5	72 F.		April 28, 1935	May 30, 1935 (4½ weeks)	10 weeks	Yes	Fair	Increasing and severe *osteo-arthritis*, June 1, 1938
6	80 F.		June 2, 1935	June 26, 1935 (24 days)	6 weeks	Yes	Good	June 14, 1938: walks well, "very little pain only at times"—now aged 83
7	70 F.	Cardio-vascular renal disease—poor risk	July 18, 1935	Aug. 8, 1935 (21 days)	6 weeks			Died 6 weeks after leaving hospital
8	70 F.	Rheumatoid arthritis (not hip)	Jan. 17, 1936	Feb. 12, 1936 (26 days)	4 months	Yes	Normal	Nov. 17, 1937: normal
9	63 F.		May 8, 1936	June 9, 1936 (4 weeks)	3 months	Yes	Good	Occasional pain—walks 2 miles and more, July 6, 1938. X-ray shows early *osteo-arthritis*
10	73 F.	Poor risk	June 17, 1936	July 10, 1936 (23 days)	3 months	No	Bad	Nail slipped and re-fracture after walking well—did not report for periodical X-ray control
11	78 M.	Chronic bronchitis; poor risk	Aug. 23, 1936	Oct. 5, 1936 (6 weeks)	—	—	—	Death, bronchopneumonia, 2 months after operation on Dec. 1, 1936
12	71 F.		Oct. 6, 1936	Nov. 6, 1936 (4 weeks)	1 month	Yes	Good	"Walks everywhere"—shortening of neck, July 14, 1938
13	77 F.		Nov. 2, 1936	Nov. 23, 1936 (3 weeks)	3 months	Yes	Fair	Nov. 19, 1937: walking with no pain about house
14	67 F.	Bronchopneumonia	March 10, 1937	May 2, 1937 (7 weeks)	9 months	Yes	Good	July 26, 1938: walks with no pain and without sticks

Table III.—Details of 16 Cases of Extra-articular Osteosynthesis with Smith-Petersen Nail and Fibular Graft for Old (over 3 weeks) and Ununited (Pseudarthrosis) Fractures

(This table includes *Cases* 13, 29, 42, in *Table I*)

Case No.	Age and Sex	Previous Treatment	Date of Fracture	Date of Operation After Fracture	Weight-bearing after Operation	Osseous Union (X-ray)	Function	Comment
1	72 F.	"Failed" extra-articular Smith-Petersen nail by me (too early walking)—March 8	March 3, 1935	Nov. 28, 1935 (over 8 months)	3 months	Yes	Fair	Sept. 8, 1936: walking improving—*osteo-arthritis* (*Case* 13, *Table I*)
2	71 F.	"Failed" traction method	20 months old	Sept. 10, 1935 (20 months)	9 months	Yes	Fair	Walks 1 mile (no support). Occasional pain, June 28, 1938. (*Figs.* 514–521)
3	60 M.	"Failed" traction method	June 11, 1935	June 24, 1936 (1 year)	5 months	Yes	Poor	Walked well 5 months, then developed *tuberculous hip* (*Fig.* 527)
4	64 F.	Delayed union, extra-articular Smith-Petersen nail by me Jan. 2	Dec. 25, 1935	July 8, 1936 (7 months)	6 months	Yes	Fair	May, 1938: walks 1½ miles—little pain. (*Case* 29, *Table I*)
5	13½ F.	"Failed" Whitman method	May 18, 1936	Sept. 1, 1936 (4 months)	6 months	Yes	Good	June 8, 1938: occasional ache (*Figs.* 499–504 and *Figs.* 510–513)
6	73 F.	"Failed" extra-articular Smith-Petersen nail by me, Oct. 9	Sept. 29, 1936	Nov. 10, 1936 (6 weeks)	6 months	Yes	Good	June 6, 1938: painless walking 1 mile. (*Case* 42, *Table I*)
7	46 M.	"Failed" traction method	Feb. 29, 1936	Oct. 7, 1936 (7½ months)	6 months	No	Fair	Nail removed too early
8	63 F.	"Failed" intra-articular Smith-Petersen nail by me	Sept. 23, 1936	March 24, 1937 (6 months)	6 months	Yes	Fair	May 3, 1938: occasional ache—walks 2 miles
9	61 F.	None	Sept. 13, 1936	Oct. 21, 1936 (5 weeks)	4½ months	Yes	Fair	Walked well at first, then pain—now walks about house. Increasing *osteo-arthritis*, April 3, 1938
10	59 F.	4 weeks untreated fracture	Oct. 30, 1936	Dec. 2, 1936 (1 month)	18 months	Yes	Fair	Although no walking for over 1 year on account of ununited tibia, *osteo-arthritis* beginning June, 1938
11	67 F.	4 weeks untreated—16 st. weight	Nov. 6, 1936	Dec. 8, 1936 (4 weeks)	2½ months	No	Poor	Too early weight-bearing on vertical fracture Group 3 (Pauwels)
12	63 F.	None	Nov. 26, 1936	Dec. 23, 1936 (1 month)	2½ months	Yes	Normal	Nov. 25, 1937: perfect
13	60 F.	Walked on impacted fracture 3 weeks, then separation	Feb. 20, 1937	March 24, 1937 (1 month)	6 months	No	Poor	Separation of fracture at 6 months
14	47 F.	Nearly 18 months old: "Failed" traction; 1 year later "failed" Smith-Petersen nail (intra-articular)	Aug. 3, 1935	April 21, 1937 (1½ years)	13 months	Yes	Good	Caput formerly degenerated—re-formed (*Figs.* 522–526). May 11, 1938: walking well, no pain
15	54 F.	Chronic uræmia	Feb. 1, 1937	March 31, 1937 (2 months)	—	No	Poor	Reduction was not exact
16	50 M.	"Failed" Whitman and 2 bone-pegging	March, 1934	Aug. 18, 1937	9 months	No	Fair	Osteotomy as well as pegging—improving, Aug. 1, 1938

depth of the hole measured by a narrow steel ruler. The fibular peg is now driven firmly into the caput femoris, using the punch to protect the end of the peg. It is not difficult to drill the bone parallel with the wire projecting from the nail without any cannulated drill or guide wire for the drill.

CONCLUSION

The caput femoris, if intact before operation which results in osseous union, is not more prone to head necrosis, with subsequent osteo-arthritic degeneration of the joint, than in recent fractures. If figures mean anything, nearly 69 per cent of old ununited fractures united osseously with bone-peg and Smith-Petersen nail treatment, and osteo-arthritis developed in nearly one-third of these, i.e., about the same percentage as in recent fractures. Of course these cases were selected, although I refused operation to a few only. When the nail alone was used, only 64 per cent united, and there was an increase in the incidence of head necrosis, but some of these cases were allowed to walk too early. The rival method—osteotomy—holds a most important place in the treatment of ununited fractures, but I do not believe that osteotomy produces anything like 100 per cent good results (report to be published later). It is too early to report my own series of osteotomies, but at the present moment I do not think osteotomy is well borne by patients much over 60, in whom the operation and post-operative treatment is more severe than extra-articular osteosynthesis; it is not infrequently followed by shock, despite what others may say to the contrary. The post-operative treatment of osteotomy, e.g., splinting, is uncomfortable, prolonged, and expensive; old people become mentally unhinged in bed, often troublesome, and the bladder becomes incontinent; stiff knees and hips result; femoral thrombosis has occurred in 3 of my cases; it is very difficult to teach them to walk even at the end of a year. The mortality for osteotomy for patients over 60 will be high, and many patients must be refused this method of treatment. In the meantime we should use osteotomy or extra-articular osteosynthesis with eclecticism. No one with experience can speak with optimism of ununited fractures. Osteosynthesis for ununited and old fractures has its place in their treatment, particularly in the following special cases:—

1. Children and young adults, i.e., aiming at the ideal; we can always perform osteotomy later if osteosynthesis is a failure.

2. Fractures under about three months old.

3. If the ununited caput is preserved after three months or later even, it will probably survive osteosynthesis, but as a rule osteotomy is better because osteo-arthritis may complicate a successful osteosynthesis.

4. Generally in old individuals of from 65 to 85, who are unsuited for osteotomy because of the three months' recumbency in a plaster apparatus, etc., and the very long return to function (e.g., one year), swollen leg, stiff knee, etc. If any operation is now justified—e.g., a six weeks-old untreated fracture—then osteo-synthesis for these people offers easy nursing and a chance of walking again.

5. As a rule, despite occasional successes, osteosynthesis cannot be recommended in fractures over three months old. For these individuals, if the fracture can be reduced (after ten days' preliminary traction), I am now inserting a central fibular peg (but no Smith-Petersen nail) and then immediately performing a Pauwels wedge osteotomy (2-in. base) as in *Figs.* 524–526. It remains to be seen if this is an improvement on a plain Lorenz or Pauwels-Schanz osteotomy. The

Lorenz operation is a simple and practical procedure, but the Pauwels osteotomy is theoretically more correct. If either is used without the preliminary osteosynthesis, the caput femoris remains as a loose ball unless it unites; there may also be two to three inches' shortening.

BIBLIOGRAPHY

ALBEE, H., *Injuries and Diseases of the Hip*, 1937.
BÖHLER, L., *Zentralb f. Chir.*, 1935, xxx, 1756; 1936, xxxviii, 2258.
BRITTAIN, H. A., *Brit. Med. Jour.*, 1938, i, 773.
BUCHEIM, W., *Deut. Zeits. f. Chir.*, 1936, 246, 439.
CAMBELL, W., *Surgery*, 1937, i, No. 4.
CRAIG, CLIFF, *Brit. Med. Jour.*, 1938, i, 920.
CRAIG, CLIFF, Personal communications.
ELMSLIE, R. C., *Brit. Med. Jour.*, 1937, i, 432.
ETTORE, M., *Rev. d'Orthop.*, 1937, No. 3.
FELSENREICH, F., *Die operat. Behandlung der frischen med. Schenkelhalsfraktur.*
FELSENREICH, F., *Zentralb. f. Chir.*, 1938, xviii, 1075.
GOETZE, O., *Surg. Gynecol. and Obst.*, 1937, Feb., 167.
HENDERSON, M., *Southern Med. Jour.*, 1934, December, 1032.
HENDERSON, M., *Arch. of Surg.*, 1937, xxxv, 419.
HENDERSON, M., Personal communications.
HESSE, *Zentralb. f. Chir.*, 1937, vi, 375.
GROVES, E. W. HEY, *Jour. Bone and Joint Surg.*, 1930, Jan., 1.
GROVES, E. W. HEY, *Brit. Med. Jour.*, 1935, ii, 491; 1936, ii, 88 (Anglo-French Surgical Meeting); 1937, ii, 358.
JOHANSSON, S., *The Operative Treatment of Collum Femoris Fractures.*
JOHANSSON, S., *Brit. Med. Jour.*, 1937, ii, 361.
KING, THOMAS, *Med. Jour. of Australia*, 1934, Jan. 6, 5; 1935, Oct. 19, 521; 1938, March 19, 536.
LANGE, F., *Die Behandlung der Knochenbruche.*
LEVEUF AND GIRODE, *Le Traitement des Fractures du Col du Fémur.*
LLOYD, E. I., *Brit. Med. Jour.*, 1938, i, 871.
LLOYD, E. I., Personal communications.
LORENZ, A., *Wien. klin. Woch.*, 1919, xxxii, 997.
MACAUSLAND, W. R., LEE, A. R., and LEE, H. G., *Surg. Gynecol. and Obst.*, 1934, April, 679.
MCMURRAY, T. P., *Jour. Bone and Joint Surg.*, 1936, xviii, 319.
MCMURRAY, T. P., *Brit. Med. Jour.*, 1938, i, 330.
MATTI, H., *Zentralb. f. Chir.*, 1936, xxv, 1442.
MATTI, H., *Archiv. f. klin. Chir.*, 1932, ii, 236.
MOUCHET, A., *Presse méd.*, 1934, xlii, 329.
MOUVILLE, P., *Acta orthop. Scand.*, 1936, vii, 107.
OMBRÉDANNE and MATHIEU, *Traité de Chirurgie orthopédique.*
ORELL, S., *Livre jubilaire (au A. Lambotte).* Bruxelles: Vromant.
PAUWELS, F., *Der Schenkenhalsbruch, ein mechanisches Problem.*
PUTTI, U., *Presse méd.*, 1937, Dec., 1841.
SCHANZ, A., *Deut. med Woch.*, 1925, li, 732.
SCHMID, W., *Der Chirurg.*, 1937, xi, 419.
SMITH-PETERSEN, M. N., *Arch. of Surg.*, 1931, xxiii, 715.
SMITH-PETERSEN, M. N., *Surg. Gynecol. and Obst.*, 1937, lxiv, 287.
SPEED, J. S., *Jour. Amer. Med. Assoc.*, 1935, xxiii, 104.
THORNTON, L., and SANDISON, C., *South American Journal*, 1935, Nov.
THORNTON, L., and SANDISON, C., *Clin. Congress Amer. Coll Surg., Chicago*, 1937, Oct.
VOSS, O., *Zentralb. f. Chir.*, 1937, xii, 686.
WATSON-JONES, R., *Brit. Jour. Surg.*, 1936, xxiii, 787.
WATSON-JONES, *Brit. Med. Jour.*, 1938, i, 481.
WHITMAN, R., Personal communications.
ZENO, L., *An. de Cir.*, 1938, iv, No. 1, 38.
ZENO, L., Personal communications.

THE PROBLEM OF 'BLACK OUT' IN AVIATION (AMAUROSIS FUGAX)

By Wing-commander P. C. LIVINGSTON

The term 'black out' is employed in flying when an aircraft is put through a manœuvre which results in a member of the crew being affected with loss of vision. The visual failure may vary from a condition of transient haze to complete temporary blindness. The force that is exerted upon the human body, setting in motion the chain of symptoms about to be described, is gravity (g). Gravity, in so far as it concerns this paper, is produced by a violent turn in the air roughly at right angles to the initial course of the aircraft while attaining the necessary speed. Under these conditions a force of 4 g implies that, owing to change of direction, the pressure exerted upon the body through its long axis is four times body-weight. This is really one way of bringing a centrifuging influence to bear upon the body fluids.

Descriptions of the symptoms by personnel of the Royal Air Force vary considerably, for there is a natural tendency to confuse the sequence of events, mixed as they invariably are with concurrent physiological and psychological happenings. In order to obtain a consistent and reliable account of what actually occurs, it is essential that a practical study be made as the result of personal experience, thus combining medical knowledge with the more intense forms of aerobatics. To make still more certain of results, it is important that the experimenter should be a qualified pilot with complete confidence in his co-pilot, as it is preferable for two to be engaged in such investigations.

During 1938 a number of standardized tests were carried out at Hendon Aerodrome, London, using a specially rigged and carefully examined Hawker Hart aircraft. The pilot who was responsible for this work was Flight-Lieutenant H. G. Lee, an officer of exceptional flying ability. Flight-Lieutenant Lee flew from the front seat, and recorded all gravity (g) factors from observations with an accelerometer suitably fitted for this purpose. Examination of the rigging of the aircraft after each flight often revealed marked stretching of the flying wires, and made frequent replacements essential. This state of affairs helps to demonstrate the great strains recorded, for it does not happen in general flying that any defects of this character occur.

The following description is based upon personal sensations experienced as a result of five distinct manœuvres in the air, starting in each case from an altitude of 10,000 feet. These were as follows :—

1. A dive to attain the speed of 175–180 m.p.h., followed by a sharp turn at the bottom to the left, the turn being maintained until the speed fell away to normal after about four turns. (Initial g = 5, falling to 4 in 25 seconds.)
2. A loop from a dive at 170 m.p.h. (Maximum g = $6\frac{1}{4}$, lasting 3 seconds.)
3. A loop from a dive at 185 m.p.h. (Maximum g = $6\frac{1}{4}$, lasting 4 seconds.)
4. A loop from a dive at 200 m.p.h. (Maximum g = $5\frac{3}{4}$, lasting 5–7 seconds.)

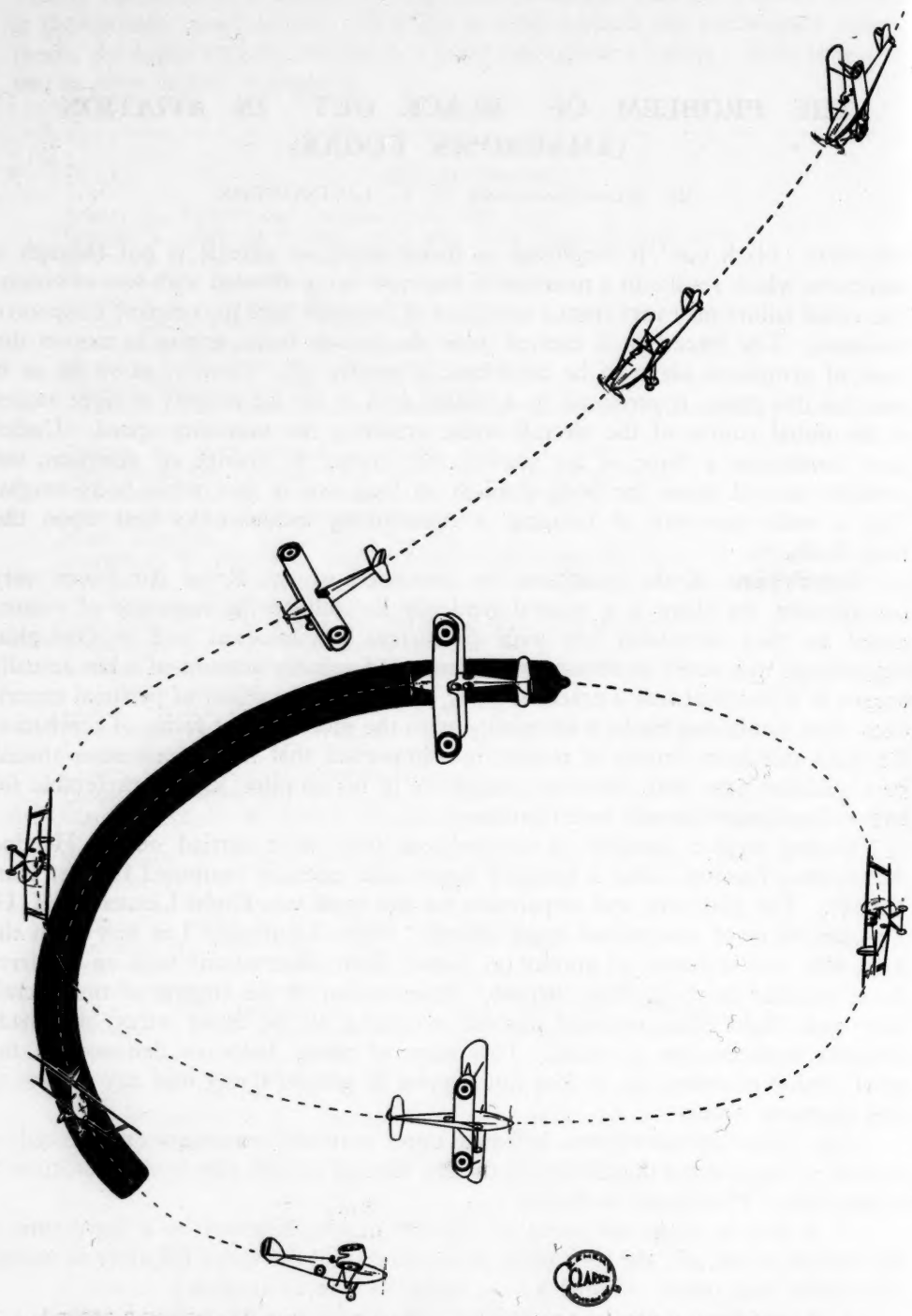


FIG. 531.—'Black out' produced by turning sharply at the bottom of a dive. The actual position of the aircraft at each phase of the movement should be observed. Onset of 'black out' and recovery shown in black. Initial gravity factor, 5 g.

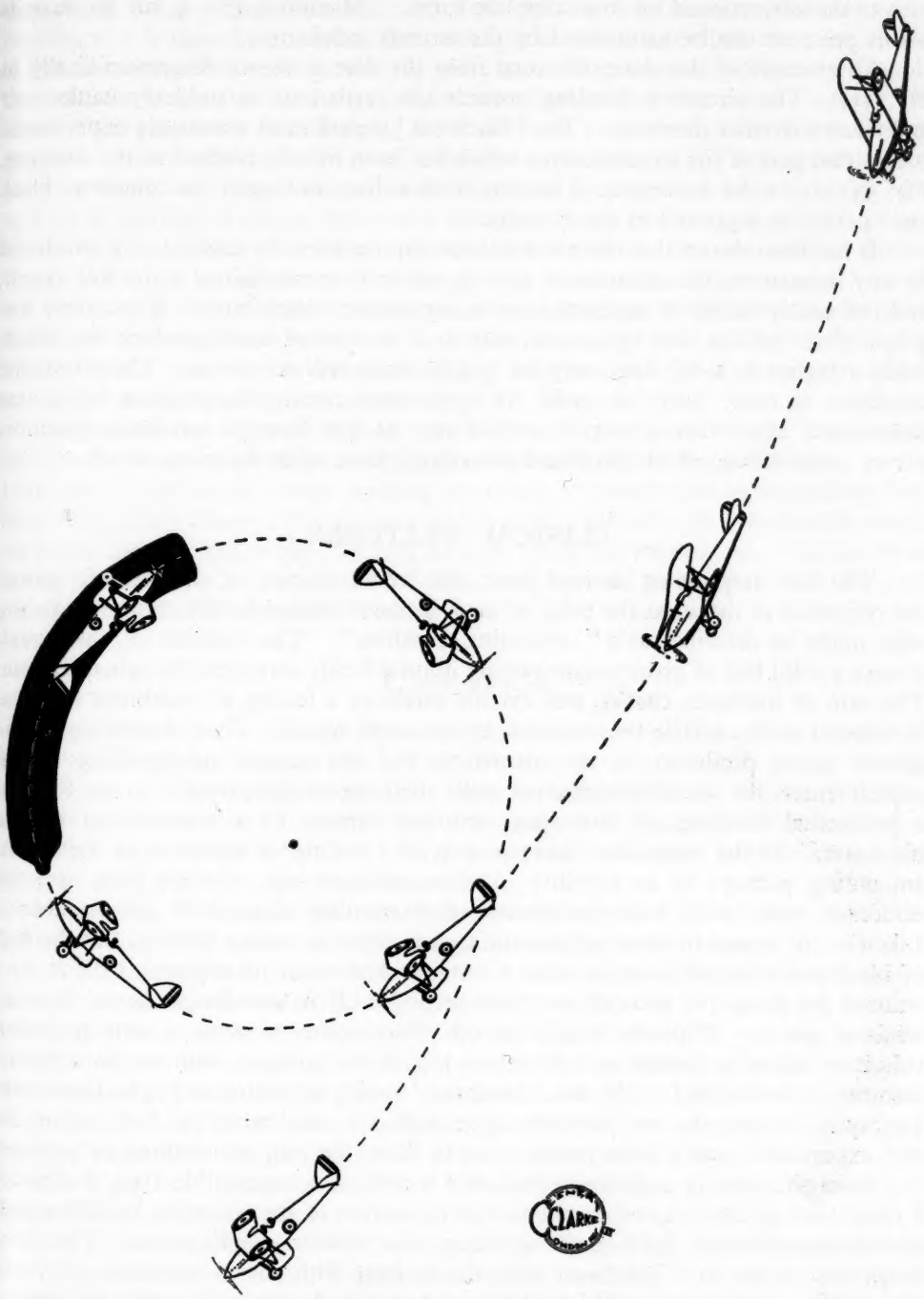


FIG. 532.—' Black out ' effected by a tight loop producing g = 6½ at 185 m.p.h. Period of blindness shown as in *Fig.* 531.

5. A dive to attain the speed of 160 m.p.h., followed by a moderately sharp turn to the left, retained for four complete turns. (Maximum g = 4, for 50 seconds —this pressure can be maintained by the aircraft indefinitely.)

An example of the sharp left turn from the dive is shown diagrammatically in *Fig.* 531. The aircraft is heading towards the earth until it suddenly banks over and takes a circular direction. The ' black out ' period most commonly experienced covers that part of the circumference which has been heavily blacked in the drawing. *Fig.* 532 shows the manœuvre of looping from a dive, and again the common ' black out ' period is suggested in the drawing.

It has been shown that there is a relationship between the amount of g produced by any manœuvre, the duration of time in which it is maintained at its full extent, and the susceptibility of experimenters to experience ' black out '. A relatively low g (4·5–5) if ' held in ' for 15 seconds may in a number of cases produce the effect, while a higher g (6–6½) kept only for 3–4 seconds will not do so. Therefore, the condition is more likely to make its appearance during sharp turns which are maintained, than when a loop is carried out, as this form of aerobatics produces a very rapid falling off of speed and centrifugal force after the initial shock.

CLINICAL FEATURES

The first impression derived from the terrific impact of the aircraft against the resistance of the air at the point of turn, is one of intense bodily strain, producing what might be described as a " concertina sensation ". The cranium feels as though it were a solid ball of great weight resting upon a feebly compressible spinal column. The skin of forehead, cheeks, and eyelids produces a feeling of numbness that can be likened to the tactile sensation on an urticarial wheal. Then, according to the gravity factor produced by the manœuvre and the natural susceptibility of the experimenter, the visual disturbances make their appearance, usually in the form of a prodromal blurring, or blue haze, followed rapidly by a sensation of intense blackness. At the same time there may arise a feeling of weakness in the limbs, amounting perhaps to an inability to move arms or legs. In my own case the blindness came with such suddenness that warning signs were almost absent. Likewise the return to visual appreciation came about in similar fashion, and the wall of blackness snapped away as does a camera shutter on its release. ' Black out ' endures for from 1–2 seconds to 12–20 seconds. If it lasts longer actual fainting tends to set in. With the longer periods there seems to come a state in which voluntary action is checked and thought is stilled, but collapse, with its characteristic features, is not reached. My own ' black out ' lasted, according to Flight-Lieutenant Lee, quite 12 seconds, and probably 15 seconds. I could recall the first turn in the first experiment, and a short period prior to flattening out, but nothing in between. Yet from this wholly negative period into which, as a susceptible type, I slipped, I came back to the full and instantaneous realization of the situation, to find myself sitting normally, still holding the speaking tube without displacement. The three loops out of the dive produced only discomfort, with just a suspicion of visual uncertainty at 200 m.p.h. The final dive and turn made purposely under less intense conditions, resulted in dimness of perception of the ground, 5000 feet below. It was as though one had overtaxed the accommodation by bringing print too near the eyes.

Subjects vary considerably with regard to their resistance to the action of centrifugal force acting from brain to feet. Of any two experimenters of equal resistence, it is more common for the passenger to 'black out' than the pilot. This is due to two factors: namely, that the pilot knows the instant in which he will apply the controls to produce a change of direction, and is therefore braced against the shock; and that he is usually flying from the front seat, where such effects are less marked. The whole matter received attention at the times of the Schneider Trophy race, as 'black out' was common, and constituted a danger. I have recently been told by a member of one of the teams that they minimized their sensations before the medical authorities, so great was their zeal to fly in the race. Short period 'black outs' are not in themselves dangerous, provided that the tests are carried out with sufficient height to allow recovery. A pilot suffering severely from the condition would lose control of his aircraft. A dive then results in which the bodily forces cease to be harmful. Thus recovery should immediately follow unless actual fainting had occurred.

After-effects.—These depend again upon the severity of the experiment, and partly, too, upon the psychological architecture of the experimenter. In the most pronounced cases, severe fainting can occur. Dreams and hallucinations have been recorded. There is the instance of the pupil pilot who, on his return to earth, sat in the hangars and sobbed for half an hour unable to be pacified. It is far more usual, however, for no persistence of signs or symptoms to be recorded. Personal experience produced no after-effects.

CAUSATION

It is clear that all this symptom-complex is the result of the blood-supply to the brain being centrifuged away. The effects of centrifugal forces acting through the long axis of the bodies of monkeys have been demonstrated in a very striking manner by V. Fischer.[1] In his paper radiographs of these animals taken before and after high acceleration show the process from normality to almost complete absence of fluids in the lungs and heart.

The most dramatic effect, namely, temporary absolute loss of sight, has been open to much speculation with regard to its essential cause or causes.

A favoured view[2] is one based on the compressing influence of intra-ocular pressure upon the central retinal artery and its branches. The vessels are believed to collapse, because the systolic drive in the ophthalmic artery is seriously impaired and the intra-ocular tension of 20 mm. of mercury provides an impassible resistance. Thus retinal nutrition is brought to a standstill. It is not possible to agree fully with this view. It is difficult to see how a uniformly distributed pressure of 20 mm. Hg can cause the occlusion of a fine, round, elastic tube, lying in the nerve-fibre layer and perfectly balanced with regard to the natural forces exerted upon it. A point of clinical interest arises. In a patient who has a deep physiological cup, it is possible to obstruct mechanically the systolic flow by pressure upon the eyeball with the finger while watching through the ophthalmoscope. The more peripheral vessels, however, do not lose their form. If, while the pressure is maintained for 2–4 seconds, the patient is asked his subjective symptoms, he does not experience blackness as understood by 'black out'. It would therefore appear that, if 'black out' in the air were due only to local conditions in the eye, then this artificially

produced collapse would also cause immediate transient blindness, which is not the case.

The retina is peculiar in so much as it is more dependent upon oxygen for the maintenance of its vitality and function than any other tissue within the body. It has been shown that the oxygen demand represents a fourfold value over other structures.[3] Were the retina deprived completely of its blood-supply, and were

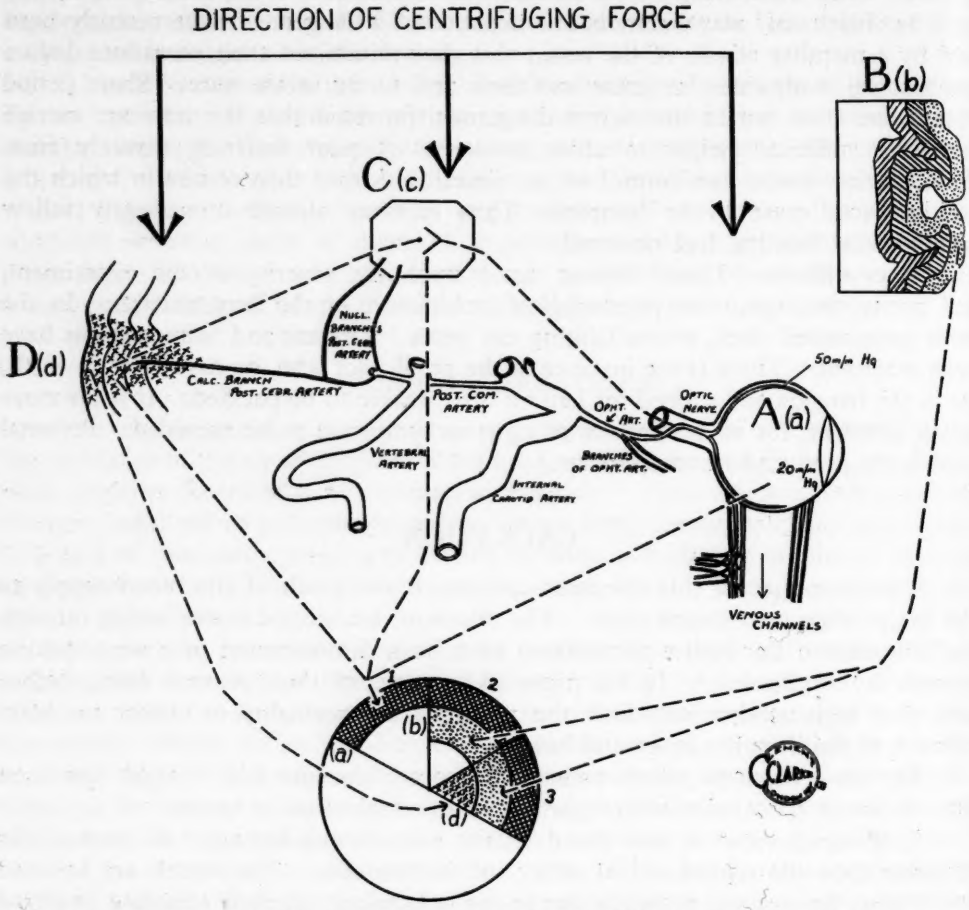


FIG. 533.—Schema covering the associated regions affected, which, according to the relative involvement of each, produce the visual and psychovisual phenomena of ' black out '.

Areas
- A, The eye with its end-artery blood-supply.
- B, Cortical area representing conscious mental processes and initiating effector responses.
- C, The area of lower visual centres, external geniculate body, pulvinar and upper quadrigeminal body, supplied by end-arteries, fulfilling the duty of intermediate relay stations.
- D, Corticovisual area.

Effects
- *a*, Visual simple ' black out ' produced through mild action at the three points (*a*), (*c*), and (*d*).
- *b*, ' Black out ' with loss of power of thought or emotional states produced by more pronounced action upon (*a*), (*b*), (*c*), and (*d*).
- *c*, ' Black out ' from profound effects upon (*a*), (*b*), (*c*), and (*d*), with emphasis on the psychovisual cortex (*d*), embodied in dream states, etc. Beyond this condition lies fainting and collapse. 1, 2, and 3 show the stages reached in diagrammatic form.

the vessels actually compressed to the point of extinction, then, in those cases where the ' black out ' period is succeeded by fainting, there would be a definite risk of permanent damage to the visual receptor mechanism. This has never been recorded. A study of the anatomy involved (*Fig.* 533) seems to add weight to the conception

that the process is not one of complete vascular denudation, but rather retardation of the existing flow. Firstly, the internal carotid artery is a particularly tortuous vessel, and it is only at the fourth bend in its ascent that the ophthalmic artery has its origin from the medial aspect. Secondly, the ophthalmic artery runs a downward as well as a forward course, which makes the vessel itself more or less immune to the vertical influence of centrifugal force. Thirdly, this artery gives off many branches more or less horizontally, and these (except the central artery) end in capillary networks that rapidly become large venous reservoirs possessing free anastomoses. Now it is reasonable to contend that there is a relatively more rapid emptying of venous blood as compared with arterial, because, although handicapped severely, the heart is still at work. It is said that increase in speed of flow at the venous outlet causes *reduction* in intra-ocular pressure.[4] Therefore, with the lessened resistance in the area of the venules, the arterial supply would tend to persist, however feebly, in spite of the drop in the systolic thrust of the internal carotid. Further, the capillary pressure in the globe itself is in the region of 50 mm. Hg, so that the margin against strangulation is really of a wide character, the more so because of the natural tendency towards a fall of intra-ocular pressure from its common 20 mm. Hg. The reduction in the internal carotid pressure must, to some extent, be opposed by its irregular course, by the semi-horizontal direction of some of its subdivisions (anterior and middle cerebral), and also by a slight negative effect through the posterior communicating artery, which would tend rather to pass towards the vertebral. Therefore, the syphonage effect at the *proximal end* of the ophthalmic artery could not, all facts considered, be as striking as might be at first believed. Nor should it be forgotten that under such conditions the whole brain must sink appreciably upon the tentorium and base of the skull, with results that well may be influential, but impossible to assess. The behaviour of the cerebrospinal fluid merits study.

When consideration is being given to a problem which involves such a complex mechanism as visual response to stimulus and the factors that may cause complete loss of visual appreciation, it is manifestly wrong to endeavour to explain the whole by confining attention to one part only of the chain. How are the lower visual centres, and the visual cortex, affected by this exsanguination? We have seen that emotional states may be brought about, that dream states arise, and that the motor power of the limbs may be impaired and the power of thought held back. This being so, it is safe to argue that the attack on vision is concentrated, not upon the retina alone, but is spread throughout the visual pathway, exercising its effect in the area of the external geniculate body, about the calcarine fissure, and upon the association tracts that raise the impulse up into the level of conscious appreciation.

METHODS USED IN COMBATING 'BLACK OUT'

These are chiefly two—postural and mechanical.

Postural.—The ideal position in which to place the crew of an aircraft for intense aerobatic flights would be with their bodies nearly parallel to the long axis of the aircraft. As this has not yet been seriously attempted, a common method is to bend the body sharply forward, thus narrowing the thigh angle at the moment of turn.[5]

Mechanical.—

1. *Adjustable Oleo Seat.*—The sudden shock which sets the centrifuging effect immediately to work could be reduced by means of a special oleo seat adjustable to various body-weights, which would tend to reduce appreciably the full influence of gravity and to spread the force over a more harmonious range, thus keeping g below the common ' black out ' point.

2. *Body Belts.*—Much experimental work has been done with various types of web elastic belts fitting about the abdomen and directly upon the skin. Credit in this country is due to the recent work of Flight-Lieutenant J. B. Wallace, M.B., who, at North Weald Aerodrome proceeded to prove that direct backward-pressure belts were of little value, but if so designed that the pressure existing could be directed *upwards* as well as backwards, a very definite improvement in the capacity to withstand the effects of g was observed.

The Influences of O_2 and CO_2.—Flight-Lieutenant Wallace believes that the free use of oxygen has little effect in holding back the onset of ' black out ', while CO_2 seems to be beneficial. Exactly how CO_2 acts in this connection is not easy to explain, because it is said[7] that a rise in blood-pressure from CO_2 inhalation depends upon the existence of peripheral dilatation, an unlikely state at 10,000 feet altitude. It is possible that, where the adrenaline influence is low, CO_2 may help to stimulate its output, and thus drive up the systolic pressure. This is a reasonable contention in view of the fact that hypotensives, who would appear susceptible subjects, do not all succumb to ' black out ', but sometimes withstand g effects very well.[8] This suggests that there are inherent individual variations between violent cardiac embarrassment and adrenaline response, such as is found with athletic strains, of which the university boat race forms a good example.

REFERENCES

[1] FISCHER, V., 1937, *Luftfahrtmedizin*, 1937, ii, 1.

[2] ANDINA, F., " Ueber ' Schwarzsehen ' abs Ausdruck von Blutdrucksschwankungen bei Struzflugen ', *Schweiz. med. Woch.*, 1937, xviii, 753.

[3] WARBURG, O., *Metabolism of Tumours*, 1937, 154. London: Constable.

[4] DUKE-ELDER, Sir STEWART, *Text book of Ophthalmology*, 1932, i, 492. London: H. Kimpton.

[5] DIRINGSHOFEN, H. VON, *Luftfahrtmedizin*, 1936, i, 226.

[6] RUFF, S., " Blood-pressure and Pulse-rate under Influence of Centrifugal Force and Attempt to Increase Tolerance of Acceleration," *Luftfahrtmedizin*, 1937, ii, 259.

[7] BOLTON, B., CARMICHAEL, E. A., and WILLIAMS, D. J., " Mechanism of the Peripheral Vascular Responses to Changes in Blood-Gas Tension in Man," *Jour. of Physiol.*, 1936, lxxxviii, 113.

[8] ROOK, A. F., and DAWSON, D. J., " Hypotension and Flying," *Lancet*, 1938, ii, 1503.

CARCINOMA OF THE LOWER END OF THE COMMON BILE-DUCT *

By JOHN C. DICK, Glasgow

The pathology of carcinoma of the bile-ducts has been described elsewhere (Renshaw, 1922; Ewing, 1928; Rolleston and McNee, 1929), but investigations as to the typical features of cancer at the lower end of the common bile-duct are becoming of increasing importance, as in recent years attempts at surgical removal have been made with considerable success (Lee and Totten, 1934; Hunt and Budd, 1935). The following report, comprising 13 cases, gives the main characteristics of carcinoma in this situation, at the same time showing how hopeful the field is for the surgeon. A comparison of the incidence of carcinoma of the gall-bladder and of the bile-ducts in general has been included to indicate the main differences between cancers in these situations.

The number of cases of cancer of the gall-bladder and bile-duct which came to autopsy in the Glasgow Royal Infirmary in the last ten years is shown in *Table I.*

Table I.—Analysis of Cases of Cancer of Gall-bladder and Bile-ducts occurring in 4239 Consecutive Autopsies (Glasgow Royal Infirmary)

	Gall-bladder	Biliary Tract	Duodenum (Ampulla of Vater)
Total	20	18	6
Number with gall-stones	18	2	1
Sex	6 M.; 14 F.	10 M.; 8 F.	4 M.; 2 F.

Altogether, these cases represented but 1 per cent of all the autopsies, yet 18 cases of carcinoma of the bile-ducts in 4239 autopsies (0·42 per cent) show that cancer in these passages is not so rare as is generally believed. Renshaw has pointed out that malignant neoplasms of the extrahepatic biliary tract are not uncommon, as he found one for every four cases of cancer of the gall-bladder. Discussing the frequency of cancer of the subhepatic region (including gall-bladder, bile-ducts, ampulla of Vater, and head of pancreas), Pelnar (1935) has compared its incidence of 13·5 per thousand autopsies with that of cancer of the stomach at 16 per thousand, and stated that "the group of subhepatic cancers shows a disquieting frequency".

It was sometimes very difficult to determine whether a carcinoma near the lower end of the common bile-duct arose within or just above the ampulla of Vater in the terminal part of either the common bile-duct or the pancreatic duct. Rolleston and McNee noted that Hanot described cancers in these sites separately,

* From the Department of Pathology of the University and Royal Infirmary, Glasgow.

though they themselves found that it was difficult or impossible to distinguish them. Ewing and Hunt and Budd also stated that it was difficult to ascertain the exact site of origin. In the series reported here, there appeared to be no case where the cancer arose in the terminal part of the pancreatic duct, and carcinomas within the ampulla are included with those of the lower end of the common bile-duct. The third column of figures in *Table I* represented a distinct group of cases where the cancer arose as far as could be determined from the duodenal mucosa over the ampulla. These cases corresponded in incidence, age, sex, and presence of gall-stones with carcinoma of the bile-ducts, although their morbid anatomy and histology corresponded with carcinomas of the intestine. Hunt and Budd stated that these were the most common peri-ampullar tumours, and noted that Springer found two-thirds of all duodenal carcinomas at the ampulla.

An interesting point is shown by comparing the numbers of cases with gall-stones: 18 out of 20 cancers of the gall-bladder had calculi, whereas only 2 out of the 18 cancers of the bile-ducts were associated with stones in the gall-bladder or bile-ducts.

The sex incidence also differed greatly in carcinomas of these situations. In the gall-bladder cancers there were more than twice as many in women as in men, whereas in bile-duct cancer men were very slightly more often affected than women.

The age incidence for this series is as follows:—

	Cases
30–39 years	1
40–49 years	5
50–59 years	9
60–69 years	24
70–79 years	4
Age not stated	1
TOTAL	44

Most of the cases occurred between 50 and 69 years—the common cancer age.

The details concerning these cases as to the occurrence of gall-stones and the sex and age incidence confirm the findings of other observers (Renshaw; Ewing; Rolleston and McNee; Judd and Gray, 1932).

An analysis of the sites of the 18 cases of cancer of the bile-ducts is given in *Table II*, along with figures from series reported by others.

Table II.—SITES OF CARCINOMA IN BILIARY TRACTS

	Cystic Duct	Hepatic Ducts	Junction of 3 Ducts	Common Bile-duct	
				Upper End	Lower End
Glasgow Royal Infirmary	3	2	—	—	13
Donati	32	—	37	48	
Rolleston and McNee	7	23	28	11	23
Judd and Gray (Mayo Clinic)	7	8	28		

In the Royal Infirmary, no case of cancer was found at the junction of the hepatic, cystic, and common bile-ducts, whereas this was a common site in other

series. The most striking point, however, is the large proportion which occurred at the lower end of the common bile-duct. (This is encouraging from the surgeon's point of view, as the operation for transduodenal resection of the ampulla of Vater holds out a fair chance of success—Hunt and Budd.)

MACROSCOPICAL APPEARANCES

The majority of these cases of cancer of the lower end of the common bile-duct presented a similar macroscopical picture (*Fig.* 534). The tumour was situated within the lower 2 cm. of the duct. Above the growth there was marked dilatation

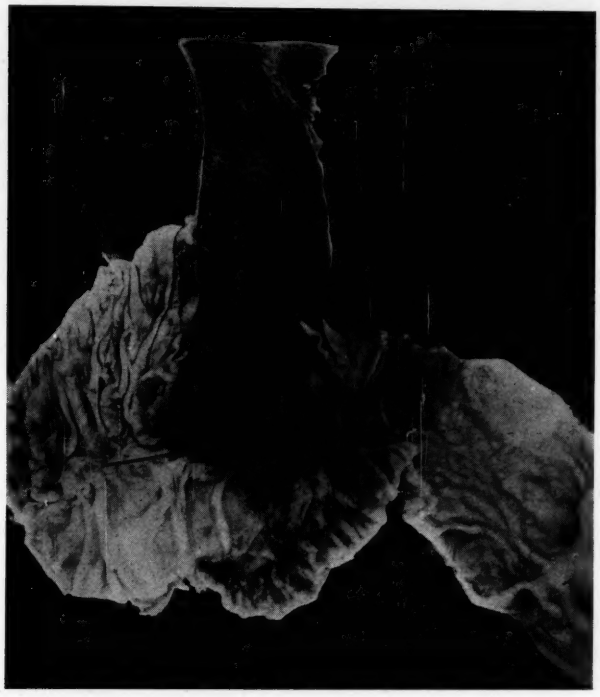


FIG. 534.—Carcinoma of lower end of common bile-duct. Duodenum and common bile-duct laid open, showing small tumour, indicated by right-hand end of bristle. Note dilatation and sacculation of common bile-duct. (× ½.)

and sacculation, with deep bile-staining of the wall of the duct. The former extended back into the hepatic ducts and small bile-ducts within the liver. In a few instances suppurative cholangitis was superadded. The cystic duct and gall-bladder were also dilated. At the lower end of the common bile-duct, the tumour caused stenosis amounting to almost complete obstruction: a fine bristle, however, could usually be passed down through the ampulla. (This corresponded with the clinical finding that the stools showed a slight degree of bile-staining, usually intermittently, indicating that small quantities of bile were occasionally passed into the intestine.) On opening up the narrowed part of the duct, the deep bile-staining of the wall ceased abruptly at the site of the growth, the wall now being white in colour, and the consistence was changed from the normal soft, yet resilient, tube to a hard, fibrous structure showing slight ulceration. The tumour

was usually very small in extent, measuring 0·4 cm. in the specimen illustrated, although one of the series was considerably larger, extending for 2 cm. along the duct. Because of the small size of the growth, it might easily have been mistaken for cicatricial contraction after ulceration, following the passage of a gall-stone. As was shown above, however, gall-stones were not often found, and histological examination of the doubtful cases proved the presence of malignancy. In eleven out of the thirteen cases at the lower end of the bile-duct, there was no extension of the tumour growth beyond the wall of the bile-duct, and no secondaries were found in lymphatic glands or other tissues. In one of the remaining cases, a papillary growth, 1·5 cm. in length, lay almost free in the lumen of the duct near the tip of the biliary papilla, although there was evidence of carcinomatous extension into the adjacent part of the duodenum; the papillomatous part was very friable and necrotic. In the last case, there was extensive infiltration of the connective tissue surrounding the lower end of the bile-duct, of the capsule and superficial part of the pancreas, and of the submucosa of the duodenum; secondary growths were present in the neighbouring lymph-nodes. As described below, this tumour showed a different histological structure from the others. Local extension and secondary growths in this type of cancer were thus unusual—a fact that has attracted the attention of others (Renshaw; Hunt and Budd) and is one of the chief indications for attempting surgical removal when this condition is suspected. Hunt and Budd and Pelnar have asserted that in cases of obstructive jaundice of unknown origin, early exploration of the abdomen is always justified, as it may disclose a cancer in an operable state.

MICROSCOPICAL APPEARANCES

Histologically, these tumours were mostly adenocarcinomata. The common type of tumour cells were large, well-formed columnar cells forming irregular acini, the cells staining darkly and mostly with well-formed nuclei; there was little evidence of anaplasia, only a slight amount of irregular proliferation and a few mitotic figures being seen (*Fig.* 535).

A very noticeable feature, present to a more or less marked degree in all the cases, was the very dense fibrosis around and between the tumour acini, without any evidence of chronic inflammation such as round-celled infiltration (*Fig.* 536). The presence of this dense stroma explained the firmness of the tumour growth in the bile-duct wall.

The well-differentiated type of cells, with the dense fibrosis and the absence of marked proliferative activity, showed that the tumour was probably of very slow growth, and explained why the primary was small and secondaries and local extensions uncommon. In the case with secondary growths, the tumour was a colloid carcinoma, showing marked cellular irregularity with metaplasia to a squamous type of epithelium, with anaplasia to polyhedral and giant cells in parts.

Caution is necessary in the histological diagnosis of carcinoma of the common bile-duct. According to Cowdry (1932) the mucous and serous glands in the subepithelial membrana propria of the bile-ducts are surrounded by connective-tissue fibres with smooth muscle bundles; this gives the appearance of epithelial cells infiltrating the muscular coat, and must be distinguished from true malignancy

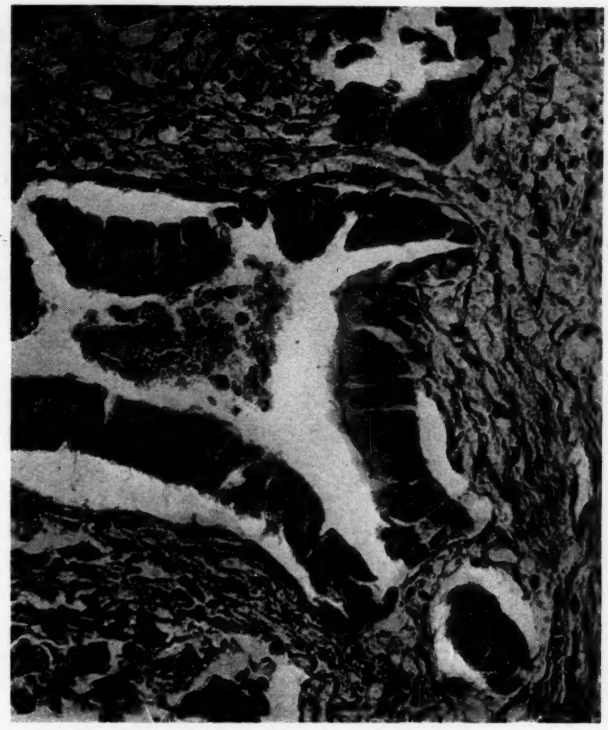


FIG. 535.—Large well-formed columnar cells lining irregular acinus. (H. and E.) (× 300.)

FIG. 536.—Dense fibrosis around and between the tumour acini. (H. and E.) (× 50.)

where there are also, in some part of the tumour, aberrations of the epithelial cells—irregular proliferation, altered staining reactions, and pyknosis, with mitotic figures in the nuclei. *Fig.* 537 shows this malignant infiltration of the bile-duct wall.

FIG. 537.—Malignant infiltration of the common bile-duct wall. (H. and E.) (× 50.)

AETIOLOGY

Various suggestions as to the aetiology of carcinoma in the bile-ducts have been advanced, and were summarized by Renshaw (1922) :—

1. Carcinoma developed on a simple papilloma in this region as is known to occur in other regions, e.g., intestine, bladder. This was first suggested by Zenker, and Rolleston quotes a case in support. One case of the series reported here also comes into this category. It does not, however, apply to the majority of cases.

2. Mayo-Robson recognized the first possibility, but thought that gall-stones were a more important factor. Ewing also suggested that the trauma due to calculi might be one of the causes. Most other observers, however, have shown that gall-stones are not frequently present in such cases, in contradistinction to cancer of the gall-bladder ; Rolleston, for example, found gall-stones in only one-third of cancers of the bile-ducts, and in 70 per cent of gall-bladder carcinomas. Devic and Gallavardin and Outerbridge obtained similar figures in their studies. The present series also minimizes the importance of gall-stones as an aetiological factor in carcinoma of the bile-ducts.

3. Rolleston was of the opinion that carcinoma might arise on an old ulcer in this situation, as in gastric carcinoma. Against this, however, is the absence of chronic ulcers in this site without carcinomas.

It is difficult to assess the value of various localizing factors while the ultimate cause of carcinoma is still unknown. Taking the conception of cancer as being due to the long-continued application of a carcinogenic agent acting in an (hereditarily) susceptible subject (Cramer, 1938), carcinoma in the bile-ducts raises the interesting point as to whether there is any ground for suspecting that the action of bile with its constituent, cholic acid (which is closely related, chemically, to some of the known carcinogenic substances—Hadfield and Garrod, 1938), may be responsible for localizing the site of development of the carcinoma in these subjects.

SUMMARY

The incidence of carcinoma of the biliary tract in the Glasgow Royal Infirmary Pathology Department for the last ten years is discussed as to frequency, site, sex, age, and the presence of gall-stones, and compared with that of carcinoma of the gall-bladder.

The macroscopic and microscopic appearance of 13 cases of carcinoma of the lower end of the common bile-duct are described: the majority are of small size and slow growth, and are shown to have a very low grade of malignancy and very rarely to metastasize. It is suggested that such growths should prove amenable to surgical treatment.

Several possible localizing aetiological factors are discussed.

This investigation was carried out during my tenure of a Foulis Memorial Scholarship, to the Trustees of which I wish to express my thanks.

REFERENCES

COWDRY, E. V., *Special Cytology*, 2nd ed., 1932, vol. i. New York.
CRAMER, W., *Brit. Med. Jour.*, 1938, i, 829.
DEVIC and GALLAVARDIN, quoted by Renshaw.
DONATI, quoted by Rolleston and McNee.
EWING, J., *Neoplastic Diseases*, 3rd ed., 1928. Philadelphia and London: Saunders.
HADFIELD, G., and GARROD, L. P., *Recent Advances in Pathology*, 3rd ed., 1938. London: Churchill.
HUNT, V. C., and BUDD, J. W., *Surg. Gynecol. and Obst.*, 1935, lxi, 651.
JUDD, E. S., and GRAY, H. K., *Ibid.*, 1932, lv, 308.
LEE, W. E., and TOTTEN, H. P., *Ann. of Surg.*, 1934, xcix, 930.
MAYO-ROBSON, A. W., and DOBSON, J. F., quoted by Renshaw.
OUTERBRIDGE, C. W., quoted by Renshaw.
PELNAR, J., *Cancer, Bruxelles*, 1935, xii, 227.
RENSHAW, K., *Ann. of Surg.*, 1922, lxxvi, 205.
ROLLESTON and MCNEE, *Diseases of the Liver, Gall-bladder and Bile-ducts*, 3rd ed., 1929. London: Macmillan.
SPRINGER, E., quoted by Hunt and Budd.
ZENKER, H., quoted by Renshaw.

THE OPERATIVE TREATMENT OF STENOSIS OF THE VESICAL NECK

By W. K. IRWIN
SURGEON, ST. PAUL'S HOSPITAL, LONDON

THIS short paper is based upon 48 operations for stenosis of the vesical neck performed by myself during the last nine years. In the majority of the cases under review sufficient time has elapsed since the operation to enable one to judge from a clinical standpoint the success or otherwise of the operative procedure. I have practised the technique which I devised in 1929 in the 48 cases without mortality, and up to the present without recurrence of obstruction.

The contracting tissue consists of two types—muscular and fibrotic—but it appears to me that these two varieties may, at least in some cases, represent merely stages of development of the same process. In a few patients, in whom the muscular tissue was predominant, there was marked hypertrophy of the internal sphincter, which was easily mobilized during operation. The other, or fibrotic, type was much the more prevalent, and represented varying degrees of fibrosis of the vesical neck. In about two-thirds of the fibrotic cases under review the obstruction apparently had involved equally the whole circumference of the internal meatus (*Fig.* 538), while in the remaining third of the patients there was elevation of the posterior lip.

A considerable difference of opinion exists with regard to causation. The hypertrophy of the internal sphincter would appear to be the result of prolonged spasm due to overaction of the sympathetic nerves. While a few of the fibrotic cases may have an inflammatory origin, I am inclined to think that a very large proportion of them are in reality due to a fibrosis which is degenerative in origin. The theory of the fibrotic changes being always of inflammatory origin lacks proof, for fibrotic stenosis of the vesical neck is met with in men free from the slightest suspicion of infection; in such cases there is no history of anything to indicate old inflammatory trouble, while on physical examination no abnormality which might suggest past infection of the organs adjacent to the vesical neck can be detected. On rectal examination the condition of the prostate gland is characterized by absence of fixation, elasticity of consistency, regularity of outline, and smoothness of surface; there is nothing, in fact, clinically to suggest prostatic infection at any time.

OPERATIVE TECHNIQUE

The bladder is exposed by a vertical suprapubic incision 2½ in. in length and opened. A finger of the left hand, on which two gloves are worn, is passed into the rectum and presses the vesical neck forwards, while the index or middle finger of the gloved right hand is pushed through the bladder neck into the prostatic urethra. The right-hand finger is now forced down in front of and below the posterior part of the vesical sphincter, and continued backwards below the anterior

part of the trigone (*Fig.* 539). The clamp-incisor, which I designed in 1929 and which is shown in the accompanying illustration (*Fig.* 542), is applied as demonstrated in *Fig.* 540, and the blade is pushed down the grooves to the end of the

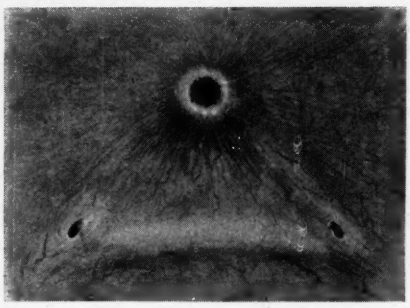


FIG. 538.—Showing an indurated stenosis of the vesical neck.

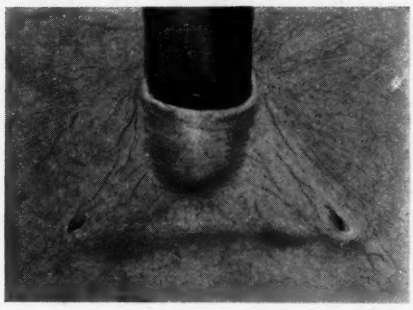


FIG. 539.—Showing a meatus after dilatation with the finger, which is demonstrated passing in front of and below the posterior part of the vesical sphincter and continued underneath the trigone.

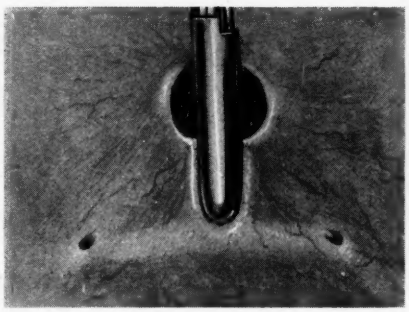


FIG. 540.—The clamp-incisor applied to sphincter and trigone.

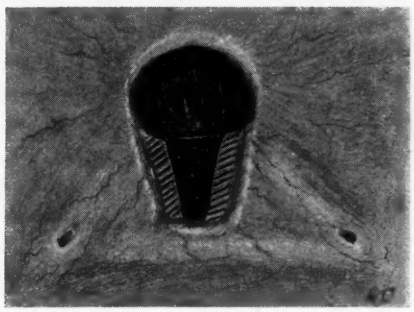


FIG. 541.—The sphincter and trigone crushed and cut.

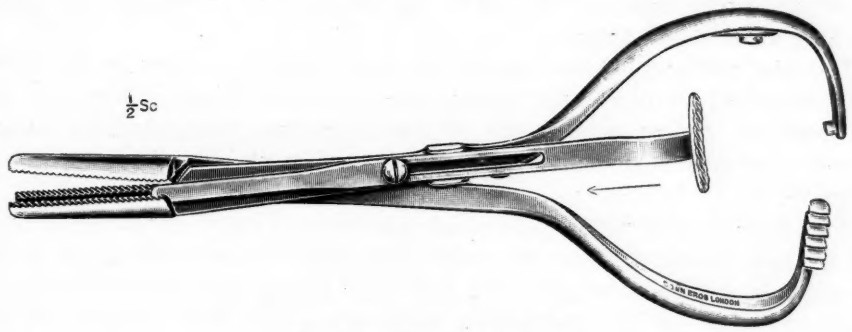


FIG. 542.—The clamp-incisor.

instrument. In this way the posterior part of the internal sphincter and the centre of the trigone for about an inch are not only divided, but thoroughly crushed on each side of the incision (*Fig.* 541). After division of the sphincter and adjacent part of the trigone, the cut edges are drawn back, leaving a large vesical neck

opening and a wide vertical gutter, thereby causing the bladder outlet to be on a much lower plane.

COMMENTARY

The surgical treatment of stenosis of the vesical neck is a subject which has been, and still is, the cause of much controversy. The need is for an operation that will cure the largest number of cases with the least risk, and the one which, in my opinion, does that, is the method described.

The advantages of this technique are :—

1. A short suprapubic incision is sufficient. If a long incision is used prolapse of the bladder mucous membrane through the suprapubic fistula, or hernia of the suprapubic scar, may result, however careful one may be in repairing the abdominal wall.

2. The operation can be performed in two stages, the subsequent division of the sphincter and trigone being done without enlarging the preliminary cystotomy opening.

3. The method is very simple and the operation is quickly performed.

4. The procedure is safe and free from post-operative complications. There need be no fear of hæmorrhage or sepsis.

5. The treatment is curative. In this series of 48 cases I have not seen any patient in whom there was a recurrence of obstruction at the vesical neck.

6. If there is any adenomatous tissue in the prostate, it can be enucleated at the same time.

When we turn to the perurethral methods of dealing with this condition we find : (1) A treatment which is incomplete, often only palliative, and which violates every principle of surgical pathology ; (2) A treatment which, owing to the possibility, or rather probability, of hæmorrhage and sepsis, is dangerous.

About five years ago a number of urologists advocated perurethral resection not only for vesical-neck stenosis but also for adenomatous enlargement of the prostate, and claimed that it would entirely replace all other methods of treatment. But the mortality from hæmorrhage and sepsis and the recurrence of obstruction at the vesical outlet soon put an end to the illusion that perurethral resection was curative and free from danger.

The chief criticism levelled against the transvesical operations by the advocates of the perurethral method is the longer time in nursing home or hospital. I have yet to meet the patient who objects to this little extra time when he learns that it means a greater degree of safety and much less chance of recurrence of the obstruction.

If we were dealing with a tube which was made of metal or wood, the principle of perurethral resection might be sound, but when we are working on a bladder neck which is highly contractile, the idea of scooping away a small piece of the urethral or vesical surface, and hoping for a cure, is far from perfect—anyhow, as far as permanent results are concerned. Surely, when we have the external sphincter to carry out the necessary function of the vesical neck the rational treatment is to put the offending internal sphincter out of action.

Complete extirpation of the bladder neck as advocated by Professor Marion evidently yields very good results, but to me the operation seems to be needlessly extensive.

CONCLUSIONS

1. The dangers and complications of the operation here described are not nearly so numerous as those of prostatectomy.

2. The method, which is complete and curative, is infinitely superior to perurethral resection, which is incomplete and often only palliative.

3. I am decidedly of the opinion that this transvesical operation is a much safer procedure than the perurethral methods of resection.

4. The operation, which is easily performed and can be completed in about ten minutes, will give results which will compare favourably, I think, with those obtained by complete extirpation of the bladder neck, as advocated by that most ingenious technician, Professor Marion.

OBSERVATIONS ON SIMPLE AND MALIGNANT PATHOLOGICAL CONDITIONS OF THE BREAST

By THIRZA REDMAN

PATHOLOGIST, BIRMINGHAM AND MIDLAND HOSPITAL FOR WOMEN

AND J. T. HEWETSON

LATE SENIOR SURGEON, BIRMINGHAM AND MIDLAND HOSPITAL FOR WOMEN

THE following paper contains a brief account of a number of pathological conditions of the breast, excluding those due to infections, and is divided into two sections: (I) Simple; (II) Malignant.

The material examined was that removed at surgical operations at the Women's Hospital, Birmingham, during the years 1929 to 1934 inclusive, and the patients have been followed up systematically for the past three years, so that we have post-operative information covering periods varying from a maximum of 8 years for patients admitted in 1929, to a minimum of 3 years for patients admitted in 1934.

Two papers[1, 2] on aetiological and statistical data referring to these cases have been published, and I do not propose to refer to those aspects in any detailed manner here, but rather to attempt to describe the main types of pathological conditions that were encountered and to show that a reasonable forecast of the end-results could be made.

PHYSIOLOGICAL CHANGES IN THE NORMAL BREAST

When first tackling the subject of breast pathology, in the course of routine work, it appeared hopelessly confusing, and the reading of a large number of original papers did not straighten out the confusion very much, although a lot of useful information was acquired. The works of Lenthal Cheatle and R. Muir were found invaluable, and, finally, E. K. Dawson's studies and personal help produced some semblance of order out of chaos and the most logical approach to the problems involved.

As Dawson says in her introductory chapters: "A knowledge of normal mammary structure is needed to interpret the actual pathological changes and to determine whether a histological picture lies within the bounds of physiological variation. It has been said that the whole problem of breast tumours, malignant and innocent, is unique, for the reason that there is no uniform standard of normal structure and function from which to deduce the pathology, but an amount of variation from time to time and from individual to individual which is without parallel in any other organ of the mammalian body."

No evidence has been found to suggest that menstruation is associated with definite glandular growth and retrogression, and there is, moreover, no true milk secretion in the proper sense of the term, as the true secreting structures are normally absent from the quiescent gland. According to Dieckmann, menstrual

changes are associated with fluid exchange in the lobular connective tissue. Premenstrually there is a physiological ordema round the lobule which produces loose connective tissue. This disappears after the period and the fibres become dense and collagenous, and scarcely distinguishable from the general supporting stroma.

The mamma during pregnancy is characterized by a great increase in the amount of glandular tissue (an adenosis), which is progressive and associated with increased vascularity. This glandular increase is produced not only by hypertrophy of existing lobules but by the formation of new lobules, the branching of the smaller ducts in pregnancy being much more complex than in quiescent tissue, but the type of structure (ductules, with two layers of epithelial cells) is similar to that of the resting tissue till after the third month of pregnancy. After the third month, simultaneously with continued glandular growth, the formation of true acini, the differentiated secreting structures, is more and more apparent. (The term " acinus " is used only for the secreting structures during pregnancy and lactation in Dawson's work.)

The formation of true acini is an uneven process and does not occur simultaneously throughout the whole breast or even a whole lobule. The acinus is the terminal outgrowth which makes the end of the glandular growth (the ductule). This terminal outgrowth throws off the superficial layer of the two lining cell-layers, and the basal layer is left as a unicellular lining to the potentially secreting structure, the acinus. The acinus varies in size and cell behaviour according to the phase of secretion at which it is examined, and has a considerable life duration. The process of lactation need not be described here, but when lactation ceases the secreting structures gradually disappear. This glandular atrophy is not a uniform process throughout the whole breast, and the varied cytological picture may be difficult to interpret. Fibrous tissue takes the place of the dead secreting elements, and in delayed or incomplete involution fibrosis and persisting adenosis may lead to fibro-adenomatosis or small multiple fibro-adenomata. Slow absorption of secretion may be caused by excessive and active fibrosis during involution. Absence or inadequacy of lactation may cause delayed involution and various sequelæ which may persist for years.

At the menopause, glandular structures normally undergo involution, when colostrum and foamy cells are very much in evidence, together with marked epithelial degeneration. The large pigmented macrophage, formed subsequently to the appearance of the foamy cell in the gland lumen, may also be observed in great numbers.

Under abnormal conditions, adenosis and its sequelæ may occur at the menopause ; also cyst formation which has no relation to previous pregnancy. Active fibrosis causes much pain in some cases, and the breasts, when removed, show a very large proportion of fibrous tissue and a small proportion of involuting glandular tissue. One patient insisted on a double amputation because of the pain ; I could find no trace of malignancy in either breast, but the amount of fibrous tissue was astonishing.

PATHOLOGICAL CONDITIONS

In section I (simple conditions) I shall speak only of the 205 cases that I have followed up and examined recently, and omit references to untraced cases, as particulars of the numbers of these have been given in a previous publication.[1]

In section II (malignant conditions) all cases—viz., 327—have been included, untraced cases being counted as dead.

I. SIMPLE PATHOLOGICAL CONDITIONS OF THE BREAST

In the group of cases diagnosed histologically as " simple " conditions, many of the operations entailed local excisions of breast tissue, and whilst it is true that the histological picture of a part of the breast may not represent that of the whole, it is of interest to note that these cases have not shown any signs of malignant disease up to the present time.

In a previous paper,[1] the various conditions were classified under five headings for the sake of simplicity—namely: (1) Chronic mastitis, 74 cases; (2) Solitary cysts, 31 cases; (3) Multiple cysts, 28 cases; (4) Fibro-adenoma, 53 cases; (5) Duct-papilloma, 19 cases—and it seems logical to adhere to the nomenclature for the time being.

1. Chronic Mastitis (74 cases).—The majority of patients sought advice as much on account of pain as of the presence of a tumour, but only 4 made the definite assertion that pain occurred immediately before and during the menstrual period. This is suggestive of engorgement of the breast and restriction of fluid exchanges in the tumour area. Evidence of this was sought, and it was found that a number of the microscopic sections showed an œdema of the supporting tissues around the ductules at the time when the period was due and also when it was just over. It was found in both single and married women aged from 20 to 40 years, all of whom had a perfectly regular cycle. It was also found in many cases where an accurate menstrual history had not been recorded.

Lobules.—In all cases there was a noticeable increase of fibrous tissue, either interlobular or intralobular, or both. In the greater proportion, degenerate lobules were present, and in patients over the age of 40, lobules were disappearing or being replaced by fibrous tissue. Adenosis was present in a few cases where babies had been born from four to seven months previously, and also in cases with histories of menorrhagia or irregularity a year or two prior to the menopause.

In one case, in which a patient aged 55 suffered from a discharge from the nipple, all the lobules were being replaced by fibrous tissue, and the ducts showed degeneration, desquamation, and lysis of epithelium with much periductal infiltration of round cells.

Dawson says that discharge from the nipple during post-menopausal mammary involution may, in rare cases, be associated with catarrhal proliferation of epithelium in the larger ducts, and little other evidence of pathological activity.

Ducts.—The state of the epithelium of the ducts varied greatly in different cases; it was degenerate in some and composed either of large poorly-staining cells or of irregular tall slim cells, or of cells of the flattened type, in others. In some ducts the epithelium was found to be desquamating.

The ducts were often distended or thrown up into corrugations; many were also blocked with finely granular material. Ductules also were often found to be distended. Round-cell infiltration was common in the presence of distended or blocked ducts.

2. Solitary Cysts (31 cases).—Two types of cyst were found—thick-walled and thin-walled—and both types occurred in all decades from the twenties to the fifties. Nearly all showed degeneration of the lining epithelium, its condition varying from

the two-layer type in some of the cysts, to a single layer of either cubical or flattened cells in others. The contents of the cysts were either thin cloudy fluid, or thick creamy material; some had been opened in the operating theatre so that no contents arrived at the laboratory.

No "pale-celled" cysts were found, and as all the operations, except one, were local excisions, it is not possible to state whether there were any present in the remaining tissues.

The length of time that had elapsed since the presence of a tumour became known, varied from 1 week to 2½ years.

There were twice as many married as single women. Of the married women 63 per cent had borne children, and about half of them had breast-fed them.

In one case, hysterectomy had been performed fourteen years before the tumour in the breast occurred. In another the menopause supervened a year after the breast operation. Neither patient had borne children or been pregnant.

3. Multiple Cysts (28 cases).—Multiple cysts were three times as prevalent in married as in single women. The age incidence was from 32 to 53 years.

Different cysts were lined with varying types of epithelium, including the ordinary two-layer, tall columnar, papillary, cubical, flattened, and pale-celled kinds. Moreover, tissue from a single case usually showed several different types of epithelial lining in different cysts.

The accompanying breast tissue removed at operation showed lobules in various stages of vitality in both single and married, parous and non-parous, subjects, irrespectively of regular and irregular menstrual cycles and of the climacteric.

Only one case could be correlated with the onset of lactation; this was in a primipara with a child of 2½ years. In the breast tissue, pale-celled cysts and cysts with papillary epithelium were predominant.

With regard to pale-celled cysts, Dawson found them in mammary tissue that had never undergone pregnancy and lactation changes, and discovered no evidence that eosinophile epithelium indicates a proliferative change with a more or less definite possibility of later malignant development.

In the present series of cases they were present in tissue from single and nulliparous women as well as in parous women, and the ages varied from 32 to 53.

Round-cell infiltration of surrounding tissue was marked in about 33 per cent of the cases in their thirties and forties, but was absent in the fifties.

4. Fibro-adenoma (53 cases).—These tumours were all removed by local excision, and there was not much of the surrounding breast tissue on which to comment.

The histogenesis is apparently as follows: First a proliferation of ductules (i.e. adenosis); then an increased production of active fibrous tissue, giving a sequence fibro-adenosis → fibro-adenomatosis → fibro-adenoma; and, occasionally, fibroma may replace fibro-adenoma.

In the majority of cases the condition was that of fibro-adenoma; 4 cases showed fibro-adenosis, and 18 fibro-adenomatosis.

Thirty patients complained of pain; 8 of these correlated the pain with the occurrence of the menstrual period. Twelve people definitely stated they had no pain, and the rest specified a feeling of local discomfort or the discovery of a lump in the breast. Twenty-eight of the thirty patients who complained of pain in the breast, had a perfectly regular menstrual cycle.

Œdema of the supporting tissues was present in a number of the cases in which pain was a prominent symptom, but only 7 accurate menstrual histories (at the time of operation) were available—3 were just before the onset of the period, 3 just after the end of the period, and 1 occurred during the period. Of cases specifying definitely that they had no pain, 4 showed œdema of the tissues at the beginning, middle, or end of the period.

The only conclusion is that œdema may be present during the menstrual period, and may be a possible cause of pain.

Lactating Fibro-adenoma.—Two cases of lactating fibro-adenomata were encountered in this series. Both occurred in primigravida and were removed in the eighth month of pregnancy, one from a woman of 29 and the other from a woman of 31 years of age. Neither patient complained of pain. Histologically they differed from ordinary fibro-adenomata in showing the presence of typical secreting acini, lined with one-layer epithelium, and with active colostrum formation in process.

The breasts from which these tumours were removed acted perfectly during lactation, and there has been no subsequent tumour-formation in either case. One patient has had two more babies and has breast-fed both of them.

Post-partum Tumours.—Two cases only gave a history of recent parturition. Both were in their early forties, one a primipara (married fourteen years) and one a multipara. Both babies were a few months old.

Case 1.—Primipara. Lump in the breast for nine months, painful at menstrual periods. Never any milk for baby, nor could any secretion be expressed from the nipples. Microscopically, not much adenosis present, only a few lobules showed any one-layer acini, and these were undergoing subinvolution. The patient reported that an uneventful menopause occurred two years later and the breast gave no trouble.

Case 2.—Multipara. Lump in the breast for two months. Microscopically, marked adenosis present and many true acini which were undergoing subinvolution. No further trouble with the breast (5 years to date) and no sign of the menopause yet.

5. Duct Papilloma (19 cases).—In these cases all except 4 were local operations, but more surrounding breast tissue was removed than in the conditions already discussed.

The duct papillomata varied in extent and complexity, and none had any appearance of malignancy as far as could be ascertained. Multiple cysts were present in the surrounding tissue in 6 cases in patients in the forties and sixties—2 cases were smooth-walled and 3 were pale-celled cysts ; the remaining case showed both types.

Comment

With a good " working knowledge " of the histology of the normal mamma at maturity, during and after pregnancy, and in the transition stages of the menopause, it appears feasible to determine the pathological conditions that will not become malignant within the limits of time mentioned in the present investigation, i.e., from 3 to 8 years after operation.

None of the 205 patients concerned have shown any signs of malignant disease up to the present time. I have been personally responsible for examining the patients, and all special cases have also been seen by their own surgeons.

II. MALIGNANT CONDITIONS OF THE BREAST

In this section, too, I feel I cannot improve upon Dawson's admirable précis of her work on carcinoma of the breast, so I do not apologize for inserting it :—

Mammary carcinoma assumes such varied forms that no satisfactory classification of tumour types has yet been made.

A logical basis for classification must rest on the morphological and histological appearances observed in the tumour tissue, and a histogenetic basis is a generally acceptable one. A detailed study of mammary tumours from this point of view has suggested that all cancers are, in their initial stages, duct cancers. The cell proliferation—epitheliosis—which tends to fill up the glandular structures, may affect a limited area or a wide extent of the corpus mammæ ; it may be a more or less ' solid filling ' or form a multilayer lining, or may show papillary character. When the cells are malignant, sooner or later the duct walls are invaded by the cancer cells, which infiltrate the surrounding stroma, eventually gaining access to the lymph-stream and reaching tissues beyond the mammary area. In the type of malignant growth which Ewing describes as diffuse cancer, there is extensive intraductal spread before any invasion is evident.

To accept the generalization that all cancers of the breast are initially duct carcinomas does not, however, imply that all malignant mammary tumours, at an early stage, present a similar histological picture. Conditions in the breast make for great variation in the morphology of mammary tissue before malignant growth emerges, and these influence the anatomical character and clinical course of the disease.

Among the conditions which produce tissue variation in the mamma may be mentioned pregnancy and lactation, menopausal instability, advanced age, etc.

Malignant growth in old patients, where the mammary tissue normally shows glandular involution and stroma quiescence, is usually slow and infiltrating, the so-called atrophic scirrhous type, in contrast to the active, cellular growth observed in young subjects and especially in lactating and pregnant women, where facilities for rapid cell proliferation and spread are afforded by a physiologically active and vascular tissue. The most important factor in influencing the type of tumour growth in the mamma seems, from our observations, to be the distortion of glandular structure produced by duct dilatation or more pronounced cyst formation. Without discussing the underlying causes of ' cystic disease ', the broad division of the mammary tissue background into cystic and non-cystic forms, makes a helpful basis for a classification of tumours if, as already suggested, we accept the position that all malignant epithelial breast tumours start as duct cancers.

A. Malignant Growth in Cystic Tissue produces what in clinical terminology is the larger, softer, cellular type of tumour, where invasion tends to be late and subsequent to considerable proliferation within dilated ducts or cysts. The ' comedo carcinomas ' are in this group.

B. Malignant Growth in Non-Cystic Tissue is characterized by an early penetration of the duct walls and entry into the surrounding stroma, which may or may not show the fibrous tissue reaction usually described as part of a scirrhous or hard tumour. The cancer cells then grow in all directions through the supporting tissue and, unless mammary involution is advanced, invade the lymph-stream and, at a clinically early stage, involve the axillary lymph-nodes. This streaming type of dissemination, especially when associated with a fibrous stroma, produces the puckered growth of hard consistence, the typical scirrhous carcinoma.

The conditions which change and deform mammary tissue before malignant growth develops may affect either a part of the breast or the whole of it in varying degree, and therefore all stages between cystic and non-cystic tissue may be found, even in the same breast. It is obvious that the malignant picture itself may thus show the widest variation in structure. It may be hard or soft ; it may affect the ducts at any level, small, medium, or large, and the glandular structures involved in the growth may be cystic or non-cystic. The cytology may be equally varied, and the degenerative changes limited or extensive. But in spite of these variations, the actual course of malignant development and extension is more or less similar in all cases. The stages of this extension form a pathological grading on an anatomical basis.

Pathological Grading of Mammary Cancer.—

a. The first stage or grade of malignant growth in the mamma is duct cancer, or, as some observers prefer to call it, intraduct cancer. Genesis may be unicentric, as seems

frequently the case in cystic papillary types, but it is often multicentric; in the diffuse or 'acute' cancers, it is apparently pluricentric.

b. The second stage shows penetration of the duct wall and progressive proliferation in the immediately surrounding tissues. The condition of these tissues influences the subsequent course of the tumour.

Where lymph and blood vascularity have been much reduced, as in older subjects, the malignant cells may grow for a considerable extent before finding their way into the lymph-stream; an additional obstacle to malignant spread in these cases is apparently presented by a dense hyaline fibrous stroma.

These two phases of tumour growth, intraductal malignant proliferation, and periductal stroma infiltration preceding the invasion of lymphatic channels, correspond to clinical Grade I.

c. The third stage of malignant spread is shown by invasion of the lymph-stream by cancer cells, a finding, in our experience, almost invariably associated with invasion of the axillary lymph-nodes. Spread through the lymph-channels depends on the movement of the lymph; early, it is apparently an embolic process; later, with slowing and diversion of the lymph-stream, it becomes a permeation. In both ways, the lymph-nodes draining the mammary area are invaded, a stage of tumour spread corresponding to clinical Grade II.

d. The later stages of malignant dissemination, as observed microscopically, may or may not have a clinical counterpart. Invasion of the pectoral muscles is usually, though not necessarily, associated with advanced—clinical Grade III—growth; spread into the perinodal tissues of the axilla is also evidence of late tumour dissemination. Invasion of perineural lymphatics and of nerve substance in the mamma or axilla is another late finding, as is also involvement of the skin beyond the mammary area.

Examination of skeletal and visceral metastases—clinical Grade IV tumour—usually suggests a blood-borne dissemination, but invasion of the blood-stream is not a frequent finding in mammary or axillary tissue removed at an operable stage of breast cancer.

In a former paper[2] referring to the cases which constitute the subject of the present work, I divided the cases into three grades, according to the clinical and pathological findings in each case. The grades (I, II, and III) mentioned later in this present work are, of course, the same as in the previous paper.

Assisted by Dawson's classification and by studies on histogenesis, I have divided the 327 cases of carcinoma into seven groups, the sixth group consisting of cases concerned with pregnancy, and the seventh consisting of cases concerned with Paget's disease of the nipple. The cases in the sixth and seventh groups are included in the first five groups and have been separated out because of their special interest for further comment.

The groups are as follows:—

	per cent
1. Duct carcinoma—	
Type 1. Epitheliosis type 47·2 per cent	56·0
Type 2. Alveolar type 8·8 „ „	
2. Scirrhous carcinoma	36·2
3. Malignant duct papilloma	4·5
4. Carcinoma with colloid degeneration	1·5
5. Intracystic carcinoma	1·5
6. Carcinoma concerned with pregnancy	1·8
7. Paget's disease of the nipple	1·1

1. Duct Carcinoma (56 per cent).—The duct carcinoma have been separated into two types: Type 1—showing massive epitheliosis arising in ducts and spreading into the surrounding tissue; and Type 2—a rudimentary kind of glandular formation (probably corresponding to what Dawson describes as of a "papillary" character). The cases designated Type 2 showed the alveolar structures very markedly, and this prompted me to put them into a separate division. The alveolar structures were not in the least like structures of a true adenocarcinoma or duct papilloma,

and were present in less degree in many other cases of duct carcinoma and scirrhous carcinoma. The reason for separating them was for the purpose of testing their relative pathogenicity. The " alveoli " were usually scattered throughout masses of epitheliomatous growth and were reproduced in secondary growths in glands. The alveolar type of duct carcinoma formed 8·8 per cent of the total number of cases, while the epitheliosis type formed 47·2 per cent of the whole.

2. Scirrhous Carcinoma (36·2 per cent).—Scirrhous carcinoma is of the same origin as duct carcinoma, hence 92 per cent of the whole series had a common histogenesis and arose from the epithelium of the ducts.

3. Malignant Duct Papilloma (4·5 per cent).—Of the cases included in this group, three-quarters were easily diagnosed and their origin was patent, but the rest presented the appearances of advanced growths of papillary adenocarcinoma, and the component elements so closely resembled parts of proven malignant duct papillomata that I have included them in this group.

4. Carcinoma with Colloid Degeneration (1·5 per cent).—With one exception, these were bulky growths in the second and third degree of the disease, and showed large collections of epitheliomatous growth mixed up with colloid material.

One very advanced growth presented the appearance of an ocean of colloid material with islets of epitheliomatous growth scattered about in an irregular fashion.

5. Intracystic Carcinoma (1·5 per cent).—I have called these " intracystic " because, in each case, the largest growths occurred within one or more cysts present in the breasts at the time of operation.

There were two types of intracystic growth: (*a*) The solid epithelial type, present in 3 cases; (*b*) The papillary type, present in 2 cases.

a. The Solid Epithelial Type of Intracystic Growth.—All the intracystic growths in these 3 cases showed the same microscopical picture in that they were of an epitheliomatous nature, penetrating the walls of the cysts and infiltrating the neighbouring tissues, but in one case the cells of the growth varied greatly in size, shape, and staining power and there was also much epitheliosis in the ducts of the parts examined. In the other 2 cases there was no epitheliosis found in the ducts of the rest of the breast.

b. The Papillary Type of Intracystic Growth.—Both cases showed intracystic malignant papillary growth. In one case the growth was apparently confined within the cyst and no infiltration of other tissue was discovered. In the other case a large portion of the breast was occupied by a mass of cysts containing malignant papillary growths and much blood; three years after a Halstead operation this growth recurred in the scar, and a mass, 3 in. in diameter, on excision proved to have the same construction of many cysts with malignant papillary growths and much blood inside them.

6. Malignant Cases Concerned with Pregnancy.—These cases are so important that I have made a place for them at this point, to draw special attention to them. They include 3 duct carcinoma, 1 scirrhous carcinoma, and 1 malignant duct papilloma, all of which are included in the respective groups, previously described.

In three cases the operations were performed during pregnancy, and in three cases the operations took place after recent pregnancy. Short notes on each case are appended.

a. During Pregnancy.—

Case 1.—No. 12437. Age 42. One month pregnant (this was not known at the time of operation). Condition: Malignant duct papilloma, Grade I. Result: Alive now (six years after operation). Child also alive and well. No secondary growth at any time.

Case 2.—No. 17598. Age 35. Three months pregnant, but aborted two weeks after Halstead operation. Condition: Malignant duct papilloma and early intraduct carcinoma, Grade I. Result: Alive now (four years after operation). No secondary growth at any time.

Case 3.—No. 12407. Age 38. Six months pregnant; hardness of the breast noticed at antenatal clinic. Condition: Advanced duct carcinoma in breast and glands, necessitating restricted operation. Result: Died seven months after operation.

b. Following Recent Pregnancy.—

Case 4.—No. 10527. Age 29. Four children; last child 4 months old. Halstead operation followed by radium implantation. Condition: Early duct carcinoma, Grade I. Result: Alive now (eight years after operation). No secondary growth at any time.

Case 5.—No. 13003. Age 29. No children; 1 miscarriage 10 months prior to operation. Condition: Very advanced duct carcinoma (restricted operation). Result: Died seven months after operation.

Case 6.—No. E 8021. Age 30. One child, 3 months old. History of lumps in the breast three months before delivery, with rapid increase in size after delivery. Condition: Scirrhous carcinoma, Grade III, too advanced for Halstead operation. Result: Died in eleven months.

RESULTS OF OPERATIONS.—Three out of these six patients are still alive, four, six, and eight years respectively after operation. Two were operated upon during pregnancy, and one after pregnancy.

All of them were in Grade I of the disease, and the breast condition in the two former was that of malignant duct papilloma, accompanied by very early intraduct carcinoma in one case (*Cases* 1, 2).

The third case showed Grade I duct carcinoma, and received radium treatment after surgical operation (*Case* 4).

The three patients who died were suffering from advanced stages of the disease. Two had duct carcinoma and lived only seven months after their operations; and the other showed scirrhous carcinoma and survived operation for eleven months.

HISTOLOGICAL SUMMARY.—

a. During Pregnancy.—In *Case* 1, one month pregnant, the lobules of the breast did not present any evidence of undue hypertrophy such as would be associated with pregnancy, and the usual microscopical appearances of malignant duct papilloma were found.

The histological picture was markedly different in *Case* 2, which was three months pregnant. The lobules were hypertrophied, and in many parts differentiated into acini with one layer of epithelium, but without secretion. Numerous small cysts and distended ducts were present. Epitheliosis and early duct carcinoma were found in some of the ducts; other ducts were full of cellular debris.

The growth of malignant duct papilloma seemed to be in process of destroying some of the lobules.

In *Case* 3, six months pregnant, the whole breast was occupied by the growth of duct carcinoma, and no secreting tissue was found.

b. After Pregnancy.—In the 2 cases of duct carcinoma (one early case and one advanced case), the appearances only differed in the degree of invasion of the breasts by the malignant growth. In the early case the greater part of the breast consisted of normal lactating tissue. In both cases the acini were lined with one layer of epithelium and many were distended with secretion.

In parts of the breasts there was a general epitheliosis in the ducts and infiltration of duct carcinoma into surrounding tissues. Growth was clearly apparent lining ducts and ductules, and tended to pile up in masses, and in the advanced case showed necrosis in parts.

In the case of advanced scirrhous carcinoma, there was a hard nodule of growth with much fibrous tissue in its immediate vicinity, surrounded by a zone of intense round-celled infiltration and some ducts full of epithelial growth. The next zone showed the disordered remains of lobules in process of destruction by the advancing malignant growth, but it was possible to distinguish that the structures had been those of true acini differentiated for the function of lactation.

In some parts of the breast, true secreting lobules still remained undisturbed.

Comment.—From the findings in the early cases it would appear that Dawson's conclusions regarding the origin of carcinoma during or following pregnancy are supported, viz., that carcinoma does not arise in the acini that are differentiated for secretion. Its origin is in the ducts lined with two layers of epithelium, and it spreads through the breast in the same manner as in the non-pregnant subject, but far more rapidly, and is often fatal in a very short time.

7. Paget's Disease of the Nipple (1·1 per cent).—Four cases showed the characteristic appearance of Paget's disease of the nipple. All were associated with duct or scirrhous carcinoma of the breast. The duration of life after operation was one year, two years, four years, and seven years, respectively, for the four cases. These were among the first cases in which I found interdermal spread of malignant cells and also the early invasion of duct epithelium by means of a malignant growth passing down a duct between the two normal layers of epithelium.

Incidence of Different Types of Growth.—Having very briefly described the various types of growth and their percentage incidence as a whole, we will now consider their percentage incidence for each grade of the disease. The figures are given in *Table I.*

Table I.—Percentage Incidence of Types of Growth in Each Grade

Grade	Duct Carcinoma			Scirrhous Carcinoma	Malignant Duct Papilloma	Colloid Carcinoma	Intracystic Carcinoma
	Both Types Together	Epitheliosis Type Alone	Alveolar Type Alone				
I	56·4	48·3	8·0	33·0	5·6	0·8	4·0
II	52·8	41·3	11·4	39·0	5·7	2·3	No cases
III	58·0	50·4	7·6	37·6	2·5	1·7	No cases

Duct Carcinoma.—Of all the cases 48·3 per cent of Grade I, 41·3 per cent of Grade II, and 50·4 per cent of Grade III cases fell into Group I (Type 1) of duct carcinoma, and 8 per cent of Grade I, 11·4 per cent of Grade II, and 7·6 per cent of Grade III cases fell into Group I (Type 2), giving a total of 56·4 per cent of Grade I, 52·8 per cent of Grade II, and 58 per cent of Grade III cases.

Scirrhous Carcinoma.—The figures for scirrhous carcinoma were lower in all grades, viz.: 33 per cent of Grade I, i.e., 23·4 per cent less than duct carcinoma; 39 per cent of Grade II, i.e., 13·8 per cent less than duct carcinoma; 37·6 per cent of Grade III, i.e., 21·6 per cent less than duct carcinoma.

There were comparatively few cases in the other three groups. The incidence of malignant duct papilloma in the different grades was 5·6 per cent in Grade I, 5·7 per cent in Grade II, and 2·5 per cent in Grade III; that of colloid carcinoma was 0·8 per cent in Grade I, 2·3 per cent in Grade II, and 1·7 per cent in Grade III. The only cases of carcinoma of intracystic origin occurred in Grade I, and constituted 4 per cent of the whole.

Survival Rates of Different Types of Growth.—The above facts suggest the very pertinent question: "Was there any difference in the pathogenicity of the various types of growth?" An attempt has been made to answer this question by working out the survival rates at the end of five years for each set of cases treated in the years 1929, 1930, 1931, and 1932, for each type of growth in each grade, and the average survival rate for all grades. The results are shown in *Table II*, and refer to a total of 217 cases.

Table II.—Percentage Survival Rates at End of Five Years for Different Types of Growth

Grade	Duct Carcinoma			Scirrhous Carcinoma	Malignant Duct Papilloma	Colloid Carcinoma	Intracystic Carcinoma
	Both Types Together	Epitheliosis Type Alone	Alveolar Type Alone				
I	65·5	66·8	71·4	62·5	100·0	No cases	33·3
II	31·0	33·3	20·0	33·3	50·0	0	No cases
III	5·2	2·85	33·3	5·5	0	0	No cases
Average for all grades	39·6	38·6	46·6	29·3	70·0	0	33·3

Grade I Cases.—All the cases survived in the malignant duct papilloma group. The next highest survival rate was in the alveolar type of duct carcinoma (71·4 per cent), which was 5 per cent greater than that of the epitheliosis type (66·8 per cent). Scirrhous carcinoma came next with 62·5 per cent and intracystic carcinoma last, with 33·3 per cent.

Grade II Cases.—The highest survival rate in Grade II was 50 per cent in the malignant duct papilloma group. Scirrhous carcinoma and the epitheliosis type of duct carcinoma showed survival rates of 33·3 per cent, while the alveolar type of duct carcinoma showed a survival rate of only 20 per cent, and no cases of the colloid carcinoma type survived.

There were no cases of intracystic carcinoma in Grade II.

Grade III Cases.—It is interesting to note that one-third of the alveolar type of duct carcinoma cases in Grade III survived, but the incidence was low. For the other types of growth, the survival rates were very much lower than those of Grade II, viz., scirrhous carcinoma, 5·5 per cent; epitheliosis type of duct carcinoma, 2·85 per cent; and 0 per cent for malignant duct papilloma and colloid carcinoma.

There were no cases of intracystic carcinoma in Grade III.

Average Survival Rates for all Grades.—Arranging the average survival rates for all grades in descending order of magnitude, we have :—

1. Malignant duct papilloma 70·0 per cent
2. Alveolar type of duct carcinoma 46·6 „ „
3. Epitheliosis type of duct carcinoma 38·3 „ „
4. Intracystic carcinoma (all cases in Grade I) 33·3 „ „
5. Scirrhous carcinoma 29·3 „ „
6. Colloid carcinoma (all cases in Grades II and III) 0·0 „ „

The highest average survival rate for all grades was that of malignant duct papilloma (70 per cent), followed by the alveolar type of duct carcinoma (46·6 per cent), which was 23·4 per cent lower than that for malignant duct papilloma.

Two points regarding the high survival rate for malignant duct papilloma must be kept in mind, viz., the condition is often diagnosed early because of the clinical signs, and the incidence in the series of cases under consideration was only 4·5 per cent.

The average survival rates for the epitheliosis type of duct carcinoma and for intracystic carcinoma were 38·3 per cent and 33·3 per cent respectively. Here again the figures for intracystic carcinoma were calculated from cases constituting only 1·5 per cent of the whole.

For scirrhous carcinoma the average survival rate was only 29·3 per cent.

No cases at all in the colloid carcinoma group were alive at the end of five years, but the incidence was the same as that of intracystic carcinoma (1·5 per cent).

Comment

1. From these facts it is not possible to make dogmatic statements concerning the pathogenicity of the different types of growth, but I would venture to say that the condition of malignant duct papilloma is apparently more curable than the other conditions, probably because it is more easily diagnosed. This also applies to the condition of simple duct papilloma, and the majority of these cases are diagnosed early and do not progress to the malignant stage.

2. The alveolar type of duct carcinoma seems less pathogenic than the epitheliosis type, and both types seem considerably less pathogenic than scirrhous carcinoma.

3. Unfortunately there are not enough cases on which to base an opinion in the intracystic and colloid carcinoma groups, interesting as they are *per se*. It can only be pointed out that in this particular set of cases intracystic carcinoma has for average survival rate 33·3 per cent and colloid carcinoma the worst result of all, viz., 0 per cent.

4. The outstanding fact, borne out by the survival rates at the end of five years, is that good results may be expected from treatment in the early stages of the disease, irrespective of the type of carcinoma, the average survival rate for Grade I, for all types, being 67·9 per cent.

By the time the disease has reached the second grade, chances of survival have been reduced by 29 per cent to 50 per cent in different types of growth, and the average survival rate for Grade II is 39·4 per cent for all types.

In Grade III very few patients survive at all, the figure being 5·2 per cent for the average survival rate for all types.

In conclusion, I should like to express my thanks to the Honorary Surgeons of the Women's Hospital, Birmingham, for allowing me to have access to their case-records, and for the special privilege of carrying out the annual follow-up examination of patients.

To the Consultant Pathologist, Professor Haswell Wilson (University of Birmingham), I am also indebted for generous help in the diagnosis of the pathological conditions in difficult cases.

My grateful acknowledgements must also be given to Dr. E. K. Dawson (Cancer Control Organization, Royal College of Physicians' Laboratory, Edinburgh) for personally showing me her wonderful collection of whole-breast sections and other preparations, and also for unstinted advice and criticism.

REFERENCES

No attempt has been made to compile a bibliography, as bigger works on the subject supply this requirement in full.

[1] Redman, T., *Birmingham Med. Rev.*, 1936, June.
[2] Redman, T., *Ibid.*, 1937, June.
[3] Dawson, E. K., *Edin. Med. Jour.*, 1933, xl, 57; 1934, xli, 653; 1935, xlii, 569.
[4] Dawson, E. K., *Cancer*, 1937. Edinburgh (Cancer Control Organization): E. & S. Livingstone.

MASSIVE NECROSIS OF THE MUSCLES OF THE LEG AFTER OPERATION FOR REMOVAL OF A BONE-GRAFT FROM THE TIBIA

By N. ROSS SMITH

HONORARY ORTHOPÆDIC SURGEON, CORNELIA HOSPITAL, POOLE, AND ROYAL VICTORIA AND WEST HANTS HOSPITAL, BOURNEMOUTH

THE following account of a surgical disaster which occured in my hospital practice some years ago is given because the experience is believed to be unique and no satisfactory explanation of the condition has yet been made.

CASE REPORT

HISTORY.—The patient was a young woman, aged 20 years, well developed and in good general condition, but fat and florid. In cold weather her face and extremities became bluish. She had been in hospital for two and a half years suffering from tuberculosis of the spine, left knee, sternum, and lungs.

THE OPERATION.—A bone-grafting operation to arthrodese the tuberculous area of the spine was done when non-operative treatment had arrested the disease in the other sites, but not in the spinal site.

A curved incision along the front of the right leg was made, the flap raised, and two massive grafts 6 in. long were cut from the medial surface of the tibia with an electrically driven saw. While these grafts were being cut, the knee was held fully flexed, but no tourniquet was used. The assistant may have exerted some pressure in holding the limb flexed. Owing to difficulties with the saw, the operation on the leg took forty-five minutes, including the opening and closing of the wound; the time of the whole operation on the leg and spine was ninety minutes. Gas-oxygen-ether anæsthesia without intratracheal tube was used, the patient lying in the prone position; during the first hour she was somewhat cyanosed. The dressing of the wound of the leg consisted of gamgee tissue, the leg being bandaged firmly, but not tightly, to a wooden back splint with foot-piece.

SUBSEQUENT PROGRESS.—After the operation, the patient said that the leg felt heavy, but there was no complaint of pain, and the toes were warm and normal in colour. There was a severe degree of shock. The next day, complete loss of sensibility and power of movement below the knee were noted, and the skin-flap of the leg wound was slightly discoloured. Subsequently the edges only of the flap sloughed; but no other area of skin in the leg or foot became necrotic. When the stitches were removed after a week, the muscles of the anterior compartment of the leg were seen to be necrotic, and sloughed completely in the following two months. During this time there was intermittent pyrexia, but there were no local signs of inflammation and no constitutional disturbances. The wound in the back healed normally. On separation of slough, a fracture of the tibia in the lower third of the shaft was noticed, but whether this occurred spontaneously or accidentally during nursing of the limb is not known.

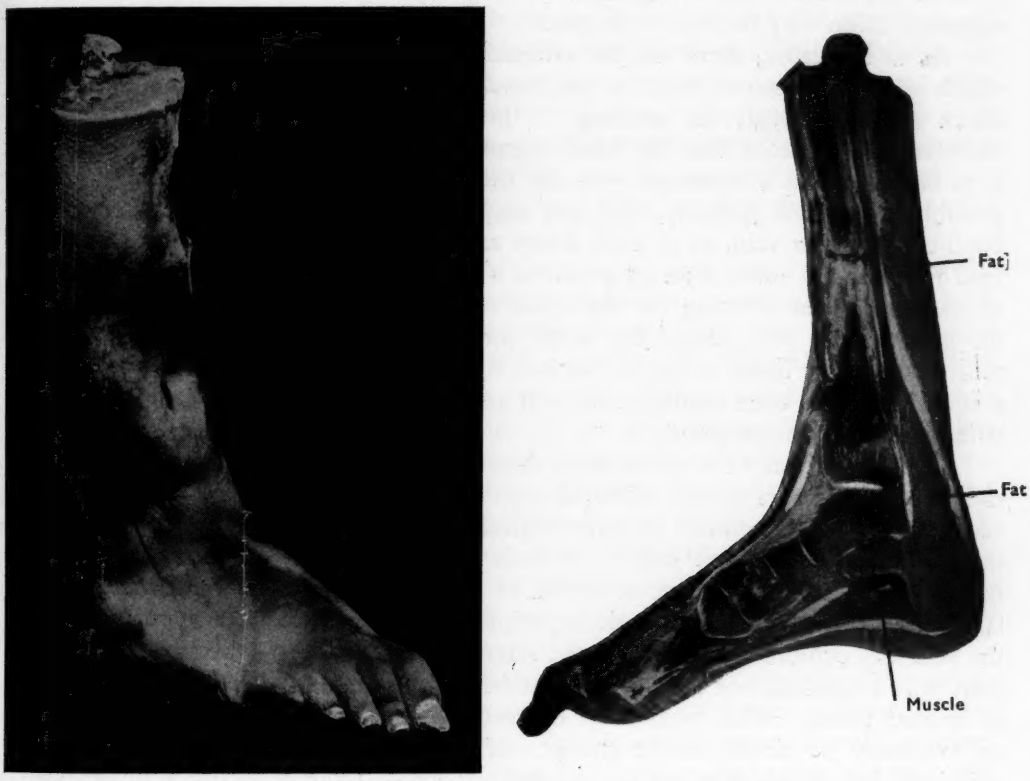
Three months after operation, the skin behind the heel, over the head of the fibula, and in the middle of the back of the leg opened, and through these openings a large amount of necrotic muscle and blood-stained serum were discharged. The openings then healed rapidly and remained healed. The skin over the plantar aspect of the head of the fifth metatarsal also gave way, with slight discharge of necrotic tissue, and subsequently did not permanently heal.

The original operation wound of the leg healed within six months, except at one point distally, where a sinus persisted permanently and led into a cavity in the lower end of the tibia. The fracture united partially in four months. No contracture of the toes or foot developed.

Five months after operation the popliteal space was explored. The blood-vessels were normal. The nerves in the distal part of the space ran through scar tissue and were freed; otherwise, they appeared normal. Six weeks later returning sensibility was first noted on the outer side of the leg.

Eighteen months after the original operation, sensibility to pin-prick had returned to the distal third of the outer side of the leg, to the middle third of the back of the leg, and to the whole of the inner side of the leg and foot. No further recovery followed in the next six months.

In view of the permanent anæsthesia, the complete loss of muscular power, and the unhealed sinuses in the front of the lower third of the leg and in the sole of the foot, amputation below the knee was performed twenty-six months after the first operation. At



FIGS. 543, 544.—Photograph of specimen and section showing necrosis of the muscles of the leg.

operation no muscular tissue was seen; the subcutaneous fat was abundant; the blood-vessels bled freely; the deep nerves were replaced by fibrous tissue. The amputation wound healed normally and the stump was sound, with normal sensibility. An artificial limb was provided. The spinal grafts were well consolidated in three months and the tuberculous disease arrested in twelve months.

THE SPECIMEN.—The amputated limb was sent to the Museum of the Royal College of Surgeons. The Pathological Curator, Dr. L. W. Proger, to whom I am indebted for the accompanying photographs (*Figs.* 543, 544) reported that the muscles in the posterior compartment of the leg had been completely replaced by fat, as had those of the anterior compartment. The muscles of the sole of the foot, though fatty, were still visible. The blood-vessels, though small, appeared normal. The cavity in the lower end of the tibia communicated with the sinus in the lower end of the operation scar; the cavity was filled with blood-clot and surrounded by pale gelatinous material embedded in spongy bone; sections of this

material showed hyaline fibrous tissue, with spicules of necrotic bone and some chronic inflammatory cells. Above the cavity in the bone the shaft was obliterated by dense new bone, at the upper limit of which there was a transverse area of softer tissue—the site of the fracture.

DISCUSSION

An examination of medical writings with the aid of the Librarian of the Royal Society of Medicine has not revealed a description or mention of any case similar to this. The outstanding features are: (1) Massive death of almost all the muscles of the limb without cutaneous gangrene, except of the margins of the wound, and without any local infective inflammation or general disturbance of health. (2) No apparent cause why necrosis took place.

As to the cause, there was no evidence of an infection or of a physical agent which might have caused death of the muscles. There was no indication of electric shock arising through the working of the saw during the operation. It must, therefore, be assumed that the blood-supply to the limb was interfered with. It is to be noted that a tourniquet was not used; but the knee was held fully flexed, possibly with some pressure, and this may well have caused compression of the popliteal artery or vein, or of both artery and vein. If this were so, the knee was held thus for not more than 45 minutes, a short time to produce death of tissues of the limb, even allowing for the effect of some previous general cyanosis from the anæsthetic. The author has never seen ill-effects from the application of a tourniquet to the thigh or leg for periods up to an hour, and it is well known that a tourniquet has been inadvertently left on a limb for even two or three hours without subsequent gangrene.

In experimental work on animals, Barney Brooks[1] found that temporary occlusion for a few hours of the principal artery or arteries of an extremity may have no demonstrable anatomical or physiological effect, but when continued for a long time (17 hours) scattered foci of necrosis or degeneration, or extensive massive necrosis of muscles and skin, occurred, in spite of resumption of pulsation in all large arteries. In isolated muscle experiments, necrosis occurred more rapidly if the vein was compressed as well as the artery. He found that muscles stand better than skin a continuously diminished blood-supply, but less well temporary absence of arterial blood. With permanent obstruction of the main artery or arteries of an extremity no demonstrable change occurred if the collateral circulation was sufficient, but if this was not so, gangrene followed more extensively in the skin than in the muscle.

Barney Brooks also observed that if the veins of a limb were temporarily obstructed without arterial obstruction, the result was acute inflammatory rather than degenerative changes in the muscles. Areas of degeneration or necrosis were seen in the muscles, but whole muscles were not necrosed. The ultimate change was fibrosis, the state seen in Volkmann's ischæmic contracture, the cause of which, Brooks concluded, was acute venous, not arterial, obstruction. Necrosis in the muscles in clinical cases of Volkmann's contracture has been noted also by Leriche,[2] Leveuf,[3] and Massart,[4] who, however, attribute the necrosis to ischæmia from arterial obstruction; but they also noted that the necrosis was confined to small scattered areas.

In a personal communication Professor Barney Brooks states that, assuming there was no infection present, he sees no possibility of explaining the case

described above other than on the basis of temporary arterial obstruction, though it is very difficult to understand how obstruction of only 45 minutes' duration could have brought about necrosis. There is, however, no doubt in his opinion that massive necrosis of muscle without necrosis of the overlying skin can be produced by temporary arterial obstruction. Apart from his experimental observation mentioned above, he has seen one instance in man in which extensive necrosis of muscle occurred without any skin manifestations. This was a patient who had marked arteriosclerosis of the popliteal vessels and developed sudden severe pain in the leg, examination several days later showing redness and tenderness of the calf. Professor Brooks attributed the condition to deep infection, and explored with the idea of opening an abscess. On cutting into the muscle it was found to be extensively necrotic. The wound was closed and healed without any infection. The patient ultimately made a good recovery, but two years later suffered another attack in which gangrene of the entire leg developed, from which he died. It was assumed that in the first attack there had been temporary complete occlusion of the popliteal vessels, which was subsequently relieved either by the development of collateral circulation or the dislodgement of a thrombus.

If it is assumed that the muscular necrosis in the case described in this article was due to interference with the blood-supply of the leg, it may have been caused, as has been said, by compression of the popliteal artery and vein by acute flexion of the knee. Alternatively it may have been caused by a hæmatoma in the popliteal space resulting from trauma during the prolonged flexion of the knee. No such hæmatoma was recognized on examination of the limb when the symptoms after operation were first noted; but the fibrosis in the space, though small in amount, noticed at the exploratory operation five months later, may have been evidence of a previous hæmatoma. The importance of this is seen in the observation reported in many cases of Volkmann's contracture of a sub-fascial hæmatoma[5] apparently responsible for pressure sufficient to cause obstruction of the circulation, notably in cases of hæmophilia[6, 7]; but again no case of massive muscular necrosis occurring in this way has been described.

Another possibility is that there occurred prolonged arterial spasm from irritation of the vasomotor nerve-fibres in the periarterial plexus of the popliteal artery. According to Leriche,[8] such a vasomotor disturbance is responsible—by primary constriction of the arteries, causing ischæmia and localized muscular necrosis, and subsequent vasodilation and hæmorrhagic infiltration—for the appearances in Volkmann's contracture, the stimulus to the vasomotor nerve-fibres on the arterial wall arising from injury or even angulation of the artery as by the fragment of a fracture at the elbow. In the case described in this article there was evidence of vasomotor imbalance in the erythrocyanosis of the extremities to which the patient was subject in cold weather. But it is difficult to imagine arterial spasm, however prolonged, producing massive necrosis of almost all the muscles of the leg without skin necrosis.

Comparison is inevitable between the case described and cases of Volkmann's contracture; but it should be noted that in this case there was complete necrosis, liquefaction, and evacuation of all muscles of the leg (except a small amount of muscle in the sole of the foot) without the subsequent fibrosis which occurs in Volkmann's contracture. It appears that no conclusion can be arrived at here as

to the cause of the phenomena described, and the case remains as a warning of a possible result of the common practice of cutting a tibial graft with the knee held acutely flexed, a practice which the author has avoided in all subsequent cases.

REFERENCES

[1] BROOKS, BARNEY, *Arch. of Surg.*, 1922, v, 188.
[2] LERICHE, R., *Bull. et Mém. Soc. nat. de Chir.*, 1935, lxi, 295.
[3] LEVEUF, M., *Ibid.*, 304.
[4] MASSART, *Rev. d'Orthop.*, 1935, xxii, 446.
[5] MIDDLETON, D. STEWART, *Lancet*, 1928, ii, 299.
[6] HILL, L. H., and BROOKS, BARNEY, *Ann. of Surg.*, 1936, ciii, 444.
[7] HEY GROVES, E. W., *Brit. Med. Jour.*, 1907, i, 611.
[8] LERICHE and POLICARD, *Physiologie pathologique, chirurgicale*, 1930. Paris: Masson et Cie.

DETACHMENT OF THE MEDIAL EPICONDYLE OF THE HUMERUS WITH DISPLACEMENT INTO THE ELBOW-JOINT*

By E. J. RADLEY SMITH
SURGICAL REGISTRAR TO KING'S COLLEGE HOSPITAL

THIS interesting condition appears to have been first described by Fairbank in 1924, when he mentioned 4 cases. As a result of violence applied to the hand or forearm, the medial humeral epicondyle is detached from the humerus and displaced into the elbow-joint, where it lies nipped between the trochlea of the humerus and the greater sigmoid notch of the ulna. I have been able to collect 32 such cases, all but 4 of which have been treated in the Orthopædic department of King's College Hospital since 1923.

Since Fairbank's original cases a good many others have been reported. My excuse for writing on this subject is the fact that some surgeons are still unfamiliar with it, and unless one is conversant with the radiological picture I find that the diagnosis is not immediately evident even when the elbow has been X-rayed.

AETIOLOGY

How does the epicondyle get into the joint? The 32 cases fall into two groups: (1) Fifteen cases in which there is proof of a dislocated elbow, after which the epicondyle was found inside the joint; (2) Seventeen cases where there has been no history or other evidence of dislocation. The second series would appear to be caused by an abduction strain on the joint, as a result of which the medial epicondyle is avulsed and the inner side of the joint therefore allowed to open in virtue of the attachment of the internal lateral ligament to the epicondyle. The epicondyle is still attached to the ulna by the internal lateral ligament, and is therefore drawn downwards until it is opposite the elbow-joint now open on the inner side. Atmospheric pressure may then force the epicondyle into the inner compartment of the elbow-joint, where it will lie between the trochlea and the sigmoid notch. After the epicondyle has been avulsed, the fate of the bony fragment probably depends upon the degree of the abducting force. If this is slight, the inner side of the joint will not be opened and we shall be left with a detached medial epicondyle outside the joint. Such an injury, leaving a detached epicondyle at any point below its normal position, is quite commonly seen. If the force is great, we may get a frank outward dislocation. In the intermediate cases, if the abducting force ceases when the epicondyle has been forced into the inner side of the joint, the bony fragment will be imprisoned between the humerus and the ulna as these bones come together again.

* Read before the Association of Surgeons of Great Britain and Ireland at their London Meeting on May 6, 1938.

The common history is a fall on the hand or inner side of the forearm. How does this begin the chain of events by avulsing the medial epicondyle? Both the internal lateral ligament of the elbow-joint and the common flexor origin are attached to the epicondyle. The abduction force is transmitted by the bones of the forearm and the internal lateral ligament to the epicondyle, and may either tear the lateral ligament or detach the epicondyle. In children it appears more common for the bone to be detached. I have never seen the epicondylar process of bone fractured off in an adult and the bony fragment displaced into the joint. Muscular contraction may also play a part, for there is no doubt that muscular contraction can avulse an epiphysis—e.g., the lesser femoral trochanter epiphysis may be torn off in running.

The cases have all occurred in adolescents—the youngest being 9 years and the oldest 17, so that the general rule that epiphyses are displaced when they are well formed or about to unite is followed. As one would expect, males predominate—in the proportion of 19 to 13. Another interesting feature of the sex incidence is the discrepancy between the average age in boys—14, and in girls—12. This is just what one might expect in view of the earlier maturity of females.

DIAGNOSIS

Clinical History.—The clinical history differs according to the aetiological type. In the first group there is a history of dislocation which may or may not have been reduced when the case is seen. In the type where there has been no frank dislocation, but rather, if we may call it so, an 'attempted dislocation', often a diagnosis of bony injury has not been made. In these instances the child may be brought for an opinion weeks after what has been considered a comparatively trivial injury because the movements are not increasing as they should or because of the development of a nerve palsy. The longest period in this series between the injury and the operation (*Case* 10) was six months. In reading the records of these cases, extending back sixteen years, I have gained the impression that the correct diagnosis has been made earlier, on the average, in the later years—doubtless as the condition has become better known to the profession.

Physical Examination.—This method may give the diagnosis, if one keeps the condition in mind, but to rely on it alone is fraught with danger. At first there may be so much swelling that one cannot be sure that the epicondyle has left its normal position. Later, it is easy to make the mistake of supposing that the epicondyle is still in position because the ridge from which it has been detached is still quite a prominent bony landmark.

Radiography.—The diagnosis is really made from the radiograph, which of course should be taken in all elbow injuries, however apparently trivial. The radiological picture of this condition is remarkably constant, but I find that a person who has not seen such a radiograph before does not immediately make the full diagnosis, particularly if he has not a picture of the normal elbow of the other arm for comparison. Both antero-posterior and lateral views are characteristic. In the antero-posterior view three points should be noted (*Fig.* 545): (1) Widening of the joint space on the inner side between the trochlea and ulna. This should be compared with the space on the outer side of the joint between the capitellum and head of the radius. (2) The presence of a bony body, either hemispherical or

FIG. 545.—Antero-posterior radiograph, with key diagram.

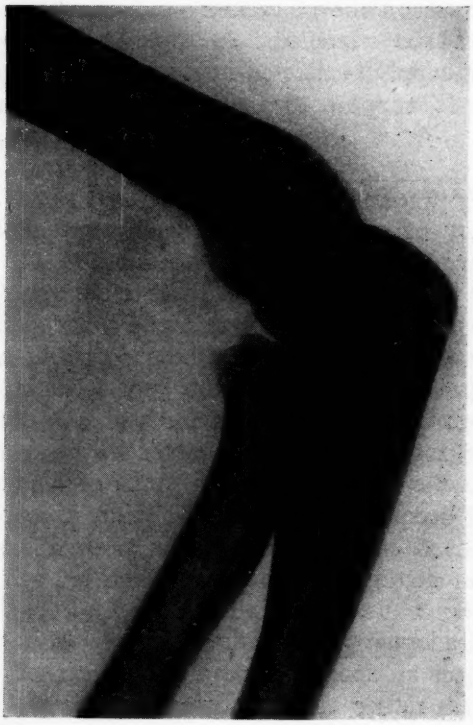


FIG. 546.—Lateral radiograph, with key diagram.

crescentic, in the joint on the inner side. (3) Loss of the medial epicondylar epiphysis from its normal position—to demonstrate this conclusively a picture of the other side is valuable.

In the lateral view (*Fig.* 546) a small shadow is seen opposite the joint space. Of course the epicondyle may be seen in a joint while it is still dislocated, and this dislocation will usually be of the outward and backward variety.

Complications.—The radiograph, then, is the important thing to be able to read correctly, but we must rely on the clinical examination to reveal a very common and important complication—a coexisting nerve palsy. An ulnar lesion was found in 23 of my 32 cases, and in 2 other cases no note of the nerve condition had been made. No other nerve has been found to be affected except the posterior interosseous in the case in which the head of the radius had been dislocated. This ulnar lesion was complete ulnar palsy in 9 cases and partial in 14. When the lesion is partial, remarkably often it consists of tingling in the little finger and weakness of the palmar interosseous muscle of that digit. In view of the high percentage of occurrence of cases of this nerve lesion, of which one-third were serious, it is most important in all cases to note definitely the presence or absence of a lesion before treatment is undertaken.

What factors cause this palsy? The nerve can be very rarely injured by direct violence, as the injury to the elbow is usually indirect. In one case the nerve was torn across, probably by the rather sharp bony ridge from which the epicondyle was avulsed. This, of course, is very rare, and the block is usually a physiological, not an anatomical, one. A hæmorrhage into or around the nerve in the elbow region may occur. Most of the trouble is due, I think, to the continued separation of the ulna and humerus, sufficient to accommodate the epicondyle between them, which must mean that any intact structure on the inner side—such as the ulnar nerve—must pursue a longer course and be stretched. In some cases I have noticed that more and more of the ulnar supply is affected in the interval between operation and injury—this perhaps lends support to the view that continued stretching is an important factor.

TREATMENT

Treatment has in the great majority of cases been by open operation, but many examples of successful manipulative reductions are being recorded. Of my cases, 30 were operated on, 1 was reduced by manipulation, and 1 was too ill to permit any treatment. The operation is not a difficult one, but when the inner side of the joint is exposed one does not realize at first glance that a bony fragment is in the joint. The common flexor origin is seen turning into the joint from below, and it quite obscures the epicondyle from which it is arising, and which is deeper in the joint. The epicondyle, of course, forms a very much larger fragment than one would have supposed by looking at the radiograph, as so much of it is still cartilaginous. After the epicondyle has been levered out of the joint, it may be sutured or nailed into position, or removed and the flexor origin sutured to the humerus. The only difficulty is met in getting the epicondyle high enough up the humerus, as it is pulled down by the contracture of the flexors.

Should any operative treatment be adopted for the ulnar palsy? In 1 case the nerve had to be sutured. In 11 cases an anterior reposition was carried out and in 12 cases not. On the whole, I am rather against moving the nerve. The

operation of anterior reposition is undoubtedly a good one where there is a continuing irritation or stretching of the ulnar nerve, but in this particular condition when the epicondyle has been replaced and the inner side of the joint allowed to close there is no continuing factor inimical to the ulnar nerve. The after-histories of the 24 cases in which an ulnar-nerve palsy was present have not shown any difference in the result whether the nerve was moved or not.

Can the operation be avoided? I have reduced one case by manipulation. The method that I adopted successfully in that case and unsuccessfully in a few others was stretching the flexor muscles by hyperextending the wrist and fingers and at the same time abducting the elbow. The latter movement opened the inner side of the joint, releasing the epicondyle, and the stretched flexors then pulled it out. Of course, by manipulation it is impossible to restore the epicondyle to quite its normal position on the humerus, as the flexors pull it down. However, the functional result of this case is perfect, although the medial epicondyle is palpably lower than in the opposite arm. From my small experience of the manipulative treatment I believe it is only successful if adopted early. This treatment has the disadvantage that one cannot inspect the ulnar nerve or move it at the time, but it seems reasonable to correct the bony defect and watch the course of the nerve lesion. If necessary an anterior reposition could be done later.

PROGNOSIS

The end-results are good. The only bad functional result was in a boy whose elbow had been dislocated and later developed myositis ossificans in the usual anterior position. Quite often there is some ossification of the internal or external lateral ligament, and this may lead to a little permanent limitation of extension. Sometimes the epicondyle is replaced a little low on the humerus, but this is compatible with a perfect functional result. The ulnar palsy frequently takes months to recover even when it was only partial, but I have only one case in which recovery was incomplete.

CASE REPORTS

The following table gives a brief outline of the 32 cases.

Case No.	Age	Sex	Type of Injury	State of Ulnar Nerve	Treatment
1	14½	M.	No dislocation	No lesion	Open reduction and suture
2	14	M.	Dislocation	Complete palsy	Epicondyle removed. Nerve transposed
3	15	M.	Dislocation	Partial palsy	Open reduction and suture
4	12	F.	Dislocation	No lesion	Open reduction and suture
5	10	F.	No dislocation	No record	Open reduction and suture
6	13	F.	Dislocation	No lesion	Open reduction and suture
7	12	F.	Dislocation	Partial palsy	Open reduction and suture and nerve transposed
8	15	M.	Dislocation	No lesion	Open reduction and suture
9	12	F.	No dislocation	No lesion	Open reduction and suture
10	15	M.	No dislocation	Complete palsy	Epicondyle removed. Nerve transposed
11	14	M.	Dislocation	No lesion	Open reduction and suture

[*Continued on next page*

CASE REPORTS—*continued*

Case No.	Age	Sex	Type of Injury	State of Ulnar Nerve	Treatment
12	11	M.	No dislocation	Complete palsy. Nerve torn across	Open reduction and suture. Nerve sutured and transposed
13	?	M.	No dislocation	Complete palsy	Open reduction and nailing. Nerve transposed
14	?	F.	Dislocation	Partial palsy	Epicondyle removed. Nerve transposed
15	14	M.	Dislocation	Complete palsy	Open reduction and suture. Nerve freed, not moved
16	12	F.	Dislocation	No lesion	Epicondyle removed
17	11½	M.	No dislocation	Partial palsy	Open reduction and suture. Nerve transposed
18	15	M.	Dislocation	Partial lesion	Open reduction and suture
19	13	M.	No dislocation	Partial lesion	Open reduction and suture
20	13	F.	No dislocation	Complete palsy	Epicondyle removed
21	12	M.	Dislocation	No record	Open reduction and suture
22	16	M.	No dislocation	Complete palsy	Open reduction and suture. Nerve transposed
23	15	M.	No dislocation	Partial palsy	Open reduction and suture. Nerve transposed
24	12	F.	Dislocation	Complete (?) palsy	Open reduction and suture. Nerve transposed
25	17	M.	No dislocation	Partial palsy	Open reduction and nailing. Nerve transposed
26	9	F.	Dislocation of head of radius	Partial palsy and posterior interosseous	Open reduction and nailing
27	16	M.	No dislocation	Partial palsy	Open reduction and nailing
28	13	M.	No dislocation	Partial palsy	Closed manipulation
29	11	F.	No dislocation	Partial palsy	Open reduction and nailing
30	11	F.	No dislocation	Partial palsy	Open reduction and nailing
31	11	F.	No dislocation	Complete (?) palsy	Open reduction and nailing
32	17	M.	Dislocation	Partial palsy	Open reduction and nailing

My most grateful thanks are due to Mr. H. A. T. Fairbank, to Mr. St. John D. Buxton, and to Mr. H. L-C. Wood for permission to use their cases, and to Mr. John B. Hunter at whose suggestion this paper was written.

CONGENITAL DISLOCATION OF THE HIP

By BRYAN McFARLAND, Liverpool

While there is little difficulty in successfully reducing the congenital dislocation of the hip-joint of a child of 3 or 4 years of age, the problem becomes more difficult when the dislocation has persisted up to the age of about 10 years. Closed reduction is seldom possible, though I have reduced a hip by the closed method as late as 12 years, fortunately without stiffness resulting. If open reduction is resorted to, a stiff hip is a common result. This is, in my opinion, due to atrophic arthritis, which in its turn is due to the pressure of the head against the acetabulum by the force of the previously shortened soft tissues. On the other hand, in many cases there is a poor acetabulum, and the absence of a good buttress against which to lodge the head of the femur makes retention of the reduced position doubtful. I have been reluctant to leave these hips alone, and although an osteotomy will often reduce some of the disability, and perhaps prevent the onset of pain in the hips and back at a later age, I have been dissatisfied with such a course. My experience of prolonged skin traction in other conditions (e.g., fracture of the femur and lengthening of the femur) led me to believe that the hip could be pulled down a considerable distance. I was surprised, however, and I think on examination of the accompanying prints others will be surprised too, at the extent to which the femoral head can be pulled downwards by skin traction.

A Thomas splint with skin traction is applied and regularly adjusted so that the traction is continuous and progressive. When the head of the femur has been pulled to below the level of the true acetabulum I usually operate and create a shelf. The anterior Smith-Petersen approach is used, and a large plaque of bone is turned down from the false acetabulum, the point of leverage being the upper rim of the true acetabulum. This is fixed in position by wedges of bone cut from the blade of the ilium. During the operation the leg is in an extended position and traction may be made on the limb. The position greatly facilitates the approach to the hip and the formation of the bony flap. Following operation, the Thomas splint with traction is continued for about six weeks, and then plaster-of-Paris is applied for about two months. Walking is then commenced.

The radiographs show what excellent results have been obtained by this method. At first there is partial stiffness of the hip, but improvement is rapid.

This method has been successfully tried in children up to 16 years of age. The method has also been applied to those cases in which, even after successful reduction, failure of development of the upper rim of the acetabulum has resulted in recurrence of dislocation. Hitherto such dislocations have been again reduced and a lip or shelf has been made by open operation, but it has been necessary to perform this with the limb in considerable abduction and to fix it afterwards in plaster-of-Paris in that position. Under the present method the limb is only slightly abducted during operation, and in this position it is maintained afterwards by a plaster-of-Paris spica. Anyone who has made a shelf with the limb in abduction

will appreciate how much easier the extended position makes the operation, and the advantage of having the limb always in a position necessary for walking will also be obvious. No less than eighteen patients have been successfully treated in this manner.

Finding skin traction so useful in preparing patients for a shelf operation, I have used it in little children as an alternative method to reduction under an anæsthetic, followed by immobilization in plaster. Radiographs (*Figs.* 560–562) show the results to be excellent. The children needed no anæsthetic. Traction is applied for

FIG. 547.—Pathological subluxation due to old suppurative arthritis, with Thomas splint in position.

FIG. 548.—By traction for two months the head was pulled well down in relation to the acetabulum, and the shelf was formed. The radiograph shows the hip fourteen months after operation.

periods of between two and four months, and the limb is then encased in plaster-of-Paris. It is usually necessary to rotate the femur internally when the plaster is being applied. Weight-bearing is not allowed for a further three or four months. The gaining in time is not considerable, but obviously the risk is less and the necessity for anæsthetics avoided.

I have also used the method for pathological dislocation of the hip (*Figs.* 547, 548).

CASE REPORTS

A detailed description is given of one patient treated (*Case* 1), and following that are some brief particulars of the others whose radiographs are illustrated.

Case 1.—M. H., a girl aged 11 years. She had been given no treatment prior to her admission. (*Fig.* 549.)

PRE-OPERATIVE TREATMENT.—On admission she was put on a Thomas splint. Skin traction (with brown holland adhesive strapping) was applied well up the thigh, and the ends were tied to the foot of the Thomas splint. In this case, and in many of the others, a ratchet type of weight extension was used. The disadvantage of a weight extension over a pulley is that the string can run both ways; but if a ratchet is introduced, each time the weight has

pulled a little, that gain is held by the ratchet (*Fig.* 551). This combines the advantages both of the fixed type of traction and the continuous weight traction. The counter-traction, mostly to relieve pressure by the ring of the Thomas splint on the skin of the groin and buttocks, is obtained by sloping the bed—the foot up and the head down.

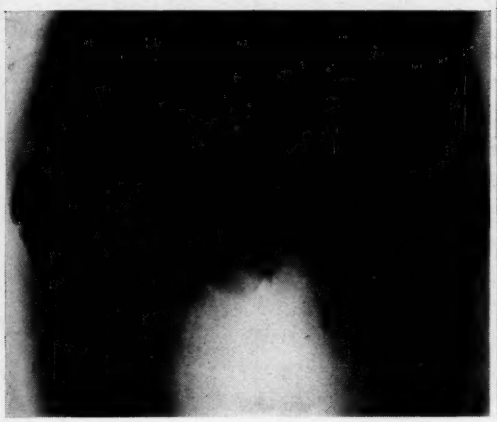


FIG. 549.—*Case* 1. Radiograph taken on admission, March 4, 1936.

FIG. 550.—Same case. After traction for four months, June 30, 1936.

After four months' traction (*Fig.* 550) in this way the leg was cleaned up and new extensions were put on, and the whole hip area prepared for operation.

AT OPERATION.—Through a Smith-Petersen antero-superior approach the acetabulum and the blade of the ilium were exposed. A crescentic incision with chisels was made into the bone obliquely downwards and inwards, and a flap of bone, consisting of part of the blade of

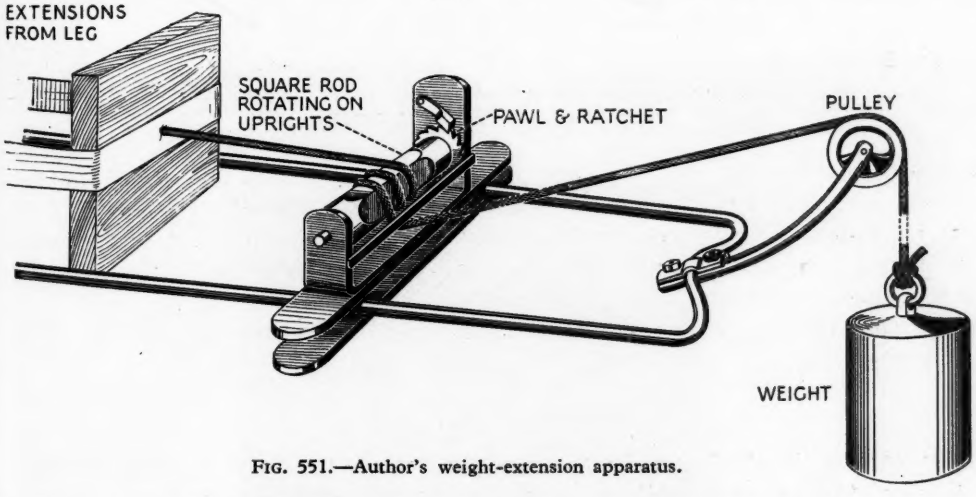


FIG. 551.—Author's weight-extension apparatus.

the ilium and the floor of the false acetabulum, was levered down over the head of the femur, traction being maintained meanwhile. Chips of cortical bone from the blade of the ilium were taken and inserted into the gap thus formed (*Fig.* 552).

Care was taken to stitch the capsule round the neck of the femur to the edge of the flap of the false acetabulum bone; thus traction on the femur was transmitted to the flap. The wound was sutured and dressed.

A Thomas splint was applied and traction continued as before operation, but with less force—in fact, only sufficient to keep the limb immobilized.

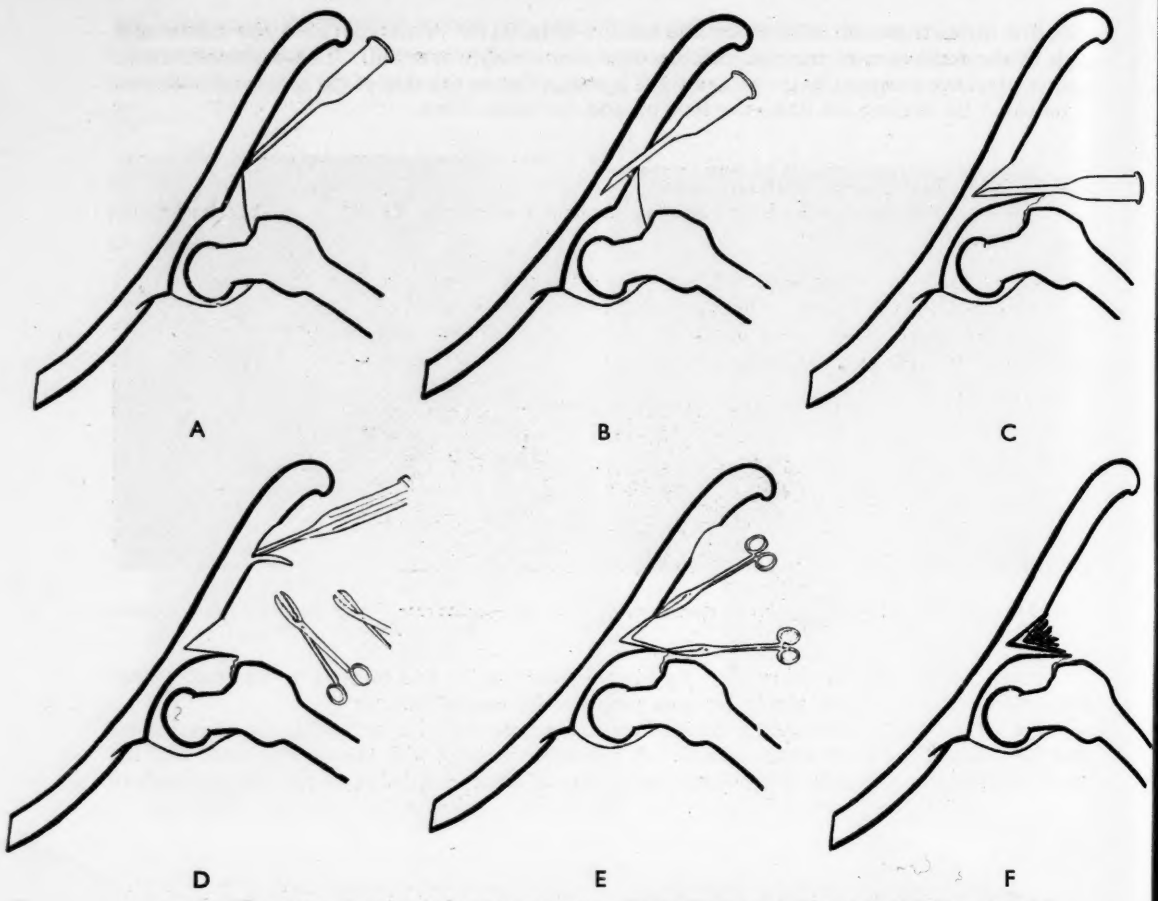


FIG. 552.—Diagram showing the formation of the acetabular roof. A, B, Incision into ilium made by chisel; C, Levering down bone flap; D, Taking cortical shaving; E, Cortical shaving bent with cancellous bone on *outside* and inserted into gap; F, Chips of bone in place.

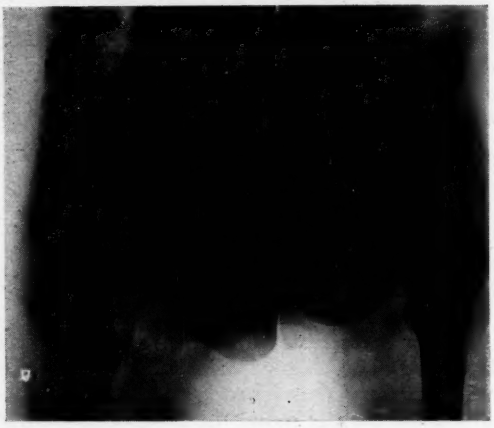


FIG. 553.—*Case* 1. The condition on Aug. 11, 1936, after operation performed July 16, 1936.

SUBSEQUENT PROGRESS.—After four months' traction (*Fig.* 553) the Thomas splint was removed and a plaster spica applied, and the patient was recumbent in this for one month.

For the next two months she commenced walking in the plaster. The walking was carefully graduated, commencing with half an hour daily, and increased up to eight hours.

At the end of two months the plaster was removed and active movements of the hip were allowed. The hip was markedly limited in movement on the removal of the plaster. With exercises, movements improved, and she was allowed up again free of all apparatus.

After another four months she was discharged walking with a slight limp, but movements almost full. The hip was perfectly stable.

She was seen six months later and had excellent function of the hip, with full movements and no limp.

Case 2.—G. H., male, aged 16½ years. Dislocation of right hip (*Fig.* 554).
May 29, 1935: Put on Thomas splint with extensions.
September 30, 1935: Operation—shelf formed. Thomas splint reapplied. (*Fig.* 555.)
November 18, 1935: Plaster spica.

FIG. 554.—*Case* 2. Dislocation of right hip, May 29, 1935.

FIG. 555.—*Case* 2. Radiograph taken Oct. 17, 1935, after four months' traction and formation of shelf on Sept. 30, 1935.

FIG. 556.—Same case. Condition on March 14, 1936. Walking (six months after operation).

March 10, 1936: Plaster removed (*Fig.* 556). Total immobilization, 10 months; Thomas splint, 6 months; plaster, 4 months.
April 7, 1936: Walking exercises.
June 10, 1936: Walking well.
October 30, 1936: Walks well. Movements very good. Real shortening, ¾ to 1 in.

Case 3.—M. L., female, aged 11½ years (*Fig.* 557). No previous treatment.
February 3, 1936: Thomas splint with extensions applied.
June 8, 1936: Openshelf operation (*Fig.* 558). Thomas splint with extensions re-applied.
August 5, 1936: Plaster spica.

FIG. 557.—*Case* 3. Dislocation of right hip Jan. 20, 1936.

FIG. 558.—*Case* 3. Radiograph, June 25, 1936, after four months' traction on Thomas's splint, followed by formation of shelf on June 8, 1936.

FIG. 559.—Same case. Radiograph taken Jan. 16, 1937, seven months after operation. Beginning to walk.

January 20, 1937: Plaster removed (*Fig.* 559). Total immobilization, 12 months: traction, 6½ months; plaster, 5½ months.
March 1, 1937: Began to walk.
August 27, 1937: Walking very well.
Present condition: Walking well; 45° flexion, almost full abduction. No outward rotation. Full length.

Case 4.—B. D., female, aged 13 months. No previous treatment.
September 20, 1934: Thomas splint applied with anæsthesia (*Fig.* 560) (see ring shadow, *Fig.* 561). Traction continued for 9 months. Skin traction with fixed extension—that is, the strings (stout blind cord) are tied to the end of the Thomas splint; counter-extension by tilting the bed with the feet up.

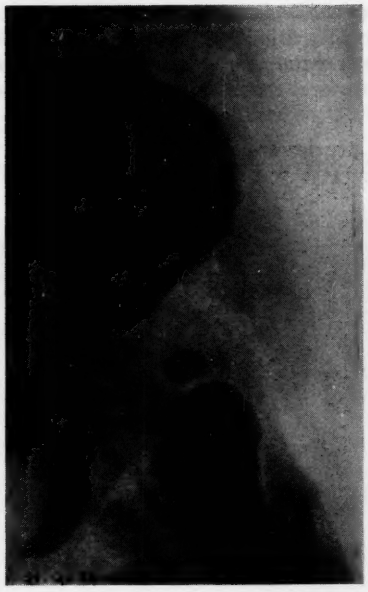


FIG. 560.—*Case* 4. Radiograph, Sept. 20, 1934. Dislocation. Note the poor acetabular roof. Upward displacement of the femur; small head.

FIG. 561.—Same case, Feb. 20, 1935, after three months' simple skin traction on a Thomas splint.

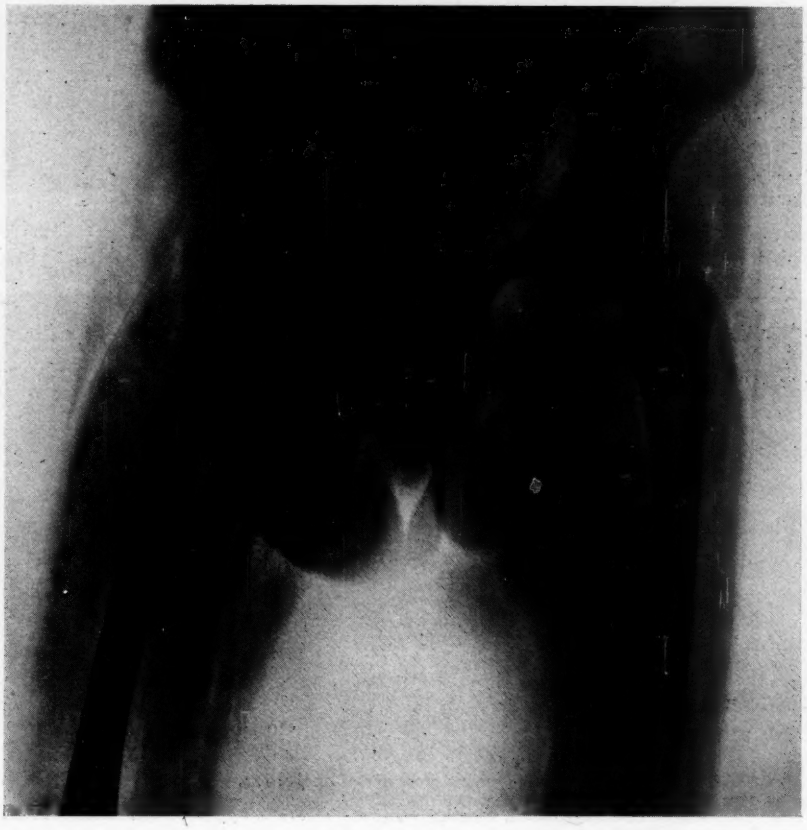


FIG. 562.—Same case, Sept. 10, 1935, a year after treatment (nine months' traction and three months' plaster) started. Note the acetabular shelf forming.

June 15, 1935: Hip put in plaster without anæsthesia.
September 10, 1935: Condition as shown in *Fig.* 562. Hip has remained in position to date.
Present condition: Excellent result. Both legs equal in length and circumference. Perfect range of movement at hip-joint. She does physical exercises at school with the other children and can turn "cartwheels" excellently.

Case 5.—N. E., female, aged 6 years (?). No previous treatment. (*Fig.* 563.)
April 16, 1935: Thomas splint with extensions (*Fig.* 564).
October 5, 1935: Shelf operation—plaster.

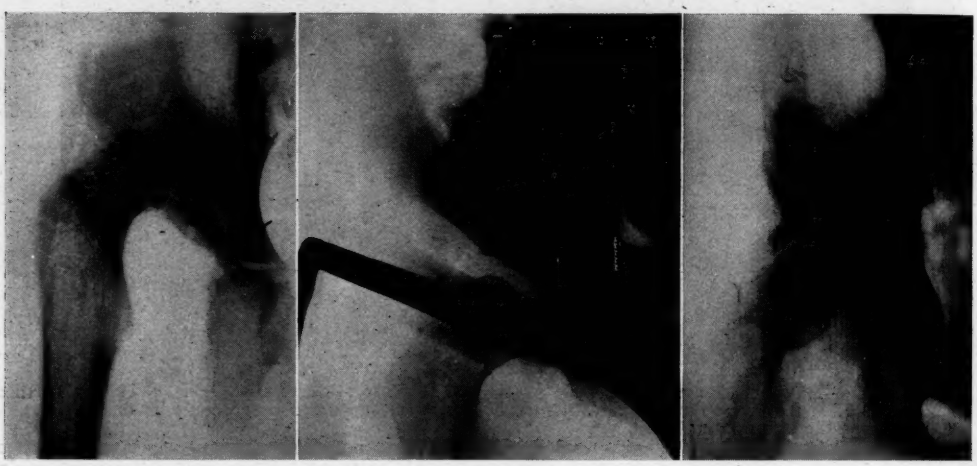


Fig. 563 *Fig.* 564 *Fig.* 565

FIG. 563.—*Case* 5. Dorsa dislocation. True acetabulum shown by arrow.
FIG. 564.—Same case after four months' traction.
FIG. 565.—Same case three months after operation. Walking.

January 11, 1936: Plaster removed. Free in bed.
February 8, 1936: Started walking (*Fig.* 565).
March 19, 1936: Discharged.
Present condition: Walking well.

Case 6.—I. M., female, aged 14 years.
October 11, 1934: Admitted. Right leg shorter than left. R.S., 2 in.; A.S., 1½ in. (*Fig.* 566).

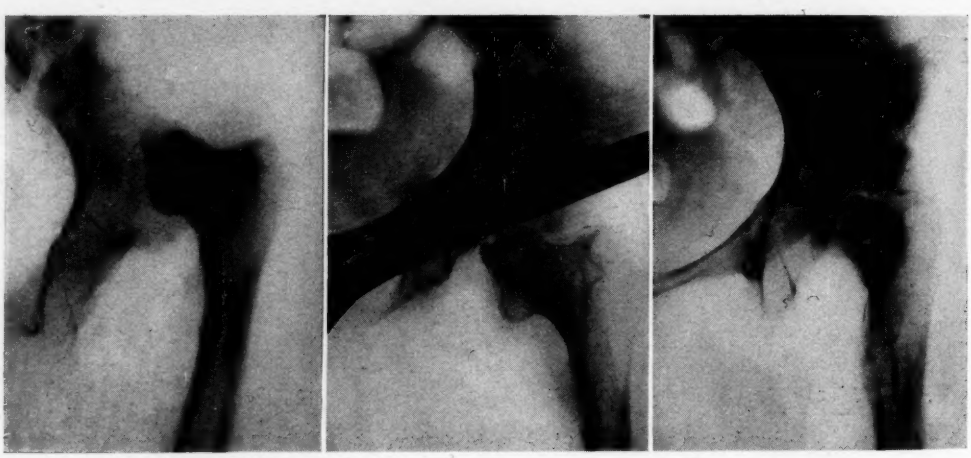


Fig. 566 *Fig.* 567 *Fig.* 563

FIG. 566.—*Case* 6. Radiograph showing gross dorsal dislocation, with considerable alteration in the shape of the head. True acetabulum shown by arrow.
FIG. 567.—Same case after eleven months' traction. Head is opposite acetabulum, which is partly obscured by ring of Thomas splint.
FIG. 568.—Same case four months after operation.

December 1, 1934: Attempted reduction by closed method. Thomas splint with extensions six to eight weeks. Continued traction, 11 months (*Fig.* 567).
September 20, 1935: Open hip operation. Thomas splint applied with strong extension.
November 16, 1935: Plaster spica.
January 4, 1936: Plaster removed (*Figs.* 568–572).
March 21, 1936: Discharged.
Present condition: Good; walking satisfactorily.

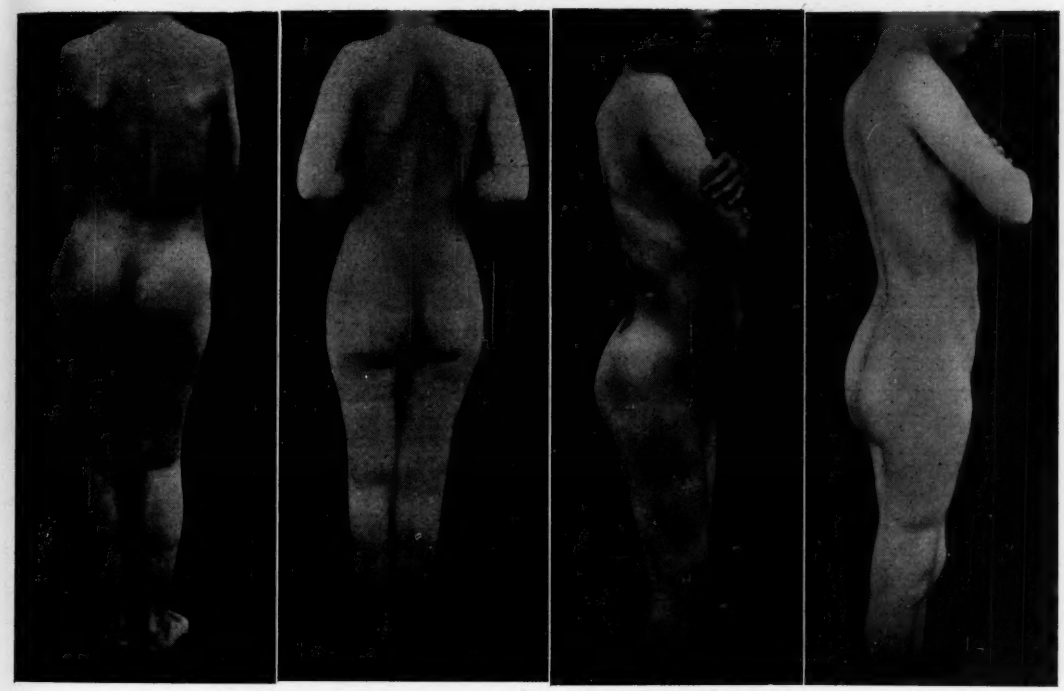


Fig. 569 *Fig.* 570 *Fig.* 571 *Fig.* 572

FIG. 569.—*Case* 6. Showing shortening before treatment.
FIG. 570.—Same case, showing absence of shortening after treatment.
FIG. 571.—Same case, showing lordosis before treatment.
FIG. 572.—Same case, showing absence of lordosis after treatment.

CHRONIC NON-TUBERCULOUS DISEASE OF THE EPIDIDYMIS

By DONALD McGAVIN
SURGICAL CHIEF ASSISTANT, ST. BARTHOLOMEW'S HOSPITAL

It is a commonplace that chronic changes in the epididymis may be due to tuberculosis or may persist after an acute phase associated with gonorrhœa, urethral stricture, gross urinary infection, or instrumentation of the urethra. But there is little or no mention in standard works that a similar condition may occur from other causes. Such cases deserve more attention than they have received in the past. Characteristically there is an insidious or subacute onset and a chronic course ending in resolution or in a stationary and apparently harmless state.

Perhaps it is rather too lightly assumed that a hard irregularity of the epididymis is tuberculous unless it is clearly due to some other cause. This assumption, if incorrect, is important because it leads to unnecessary operation, or, where conservative measures are used, to their being given credit for cures that would have come about without medical interference.

During a recent period of two and a half years 21 patients were operated upon at St. Bartholomew's Hospital with diagnoses of tuberculous epididymitis, and the material removed was submitted to histological examination. Of these 21 cases 7 proved not to be tuberculous (33 per cent). It is quite probable that such a series is representative of the cases treated at any large general hospital. Irrelevant matter and most negative points have been omitted from the reports.

CASE REPORTS

Case 1.—

History.—A student, aged 24, had noticed tenderness and swelling of his left testicle, accompanied by malaise, three and a half months before admission. By the end of a fortnight all that remained was a nodule, the size of a cherry and not tender, in the lower pole of the epididymis. This gradually increased in size. He had occasional sharp pain in his left groin, but none in his back. One week before admission he had a second and similar attack, leaving the nodule larger and tender. There had been no disturbance of micturition, no sweats, and no loss of weight. He had not had gonorrhœa. There was no personal or family history of tuberculosis. Six months before admission he had pricked a sebaceous cyst in the lobe of his ear; this had become septic, and culture had grown the *B. coli*.

On Examination.—A firm nodule, 1 × ¼ in., was present in the lower pole of the left epididymis. The body of the testis, the vas, the prostate, and the seminal vesicles were normal. Radiographs, plain and after uroselectan, did not suggest any disease of the urinary tract.

At Operation.—Orchidectomy was performed. On section the globus minor was found to be replaced by a small cavity containing necrotic cells and polymorphonuclear leucocytes, with a profuse endothelial and fibroblastic reaction in the surrounding tissue. There was no evidence of tuberculosis.

Case 2.—

History.—A waiter, aged 31, three and a half months before admission to hospital noticed an ill-localized pain across his back, worse on standing and eased by lying down. A few days later he had penile irritation on micturition, but no increased frequency. A month later he also felt rectal irritation, unrelated to defæcation or micturition.

One month before admission the pain in his back had almost disappeared, but he complained of pain in his groins, worse on the right, on walking, and made worse by straining at stool; it was much eased by a suspensory bandage. At the same time a swelling was found in the right epididymis in the globus minor, and this had become a little smaller by the time he came into hospital. Apart from the irritation in the penis at the onset, there were no abnormalities of micturition, nor any general symptoms suggesting tuberculosis. He had not had venereal disease. There was no family history of tuberculosis.

ON EXAMINATION.—There was a hard enlargement in the globus minor of the right epididymis. The vas and cord were normal. There were irregularities in both sides of the prostate, although it was not enlarged, and both seminal vesicles were palpable. A centrifuged deposit of urine showed 10 leucocytes to each $\frac{1}{6}$-in. field and no erythrocytes; cultures were sterile. The urine was slightly alkaline and, judging after the event, insufficient attention was given to this fact; another culture might have grown some organism. Radiographs of the chest and urinary tract, including intravenous pyelography, did not give any evidence of disease. A few hours before operation the left epididymis became painful and began to swell.

AT OPERATION.—Bilateral epididymectomy was carried out. In the left epididymis and vas there were inflammatory infiltration and loss of epithelium, with pus in the vasa efferentia. On the right side the changes were similar, with fibrosis and more advanced epithelial destruction. There was no evidence of tuberculosis, the picture suggesting an organizing pyogenic infection.

Case 3.—

HISTORY.—A meat salesman, aged 55, noticed a swelling of the right testicle seven weeks before admission. It had become larger and softer during the interval. There had been neither injury nor pain, nor had there been any abnormality of micturition. An attack of gonorrhœa had been treated twenty-eight years before, with no untoward sequelæ. Forty years before he had suffered from pleurisy with influenza. A sister had died from consumption.

ON EXAMINATION.—There was a diffuse enlargement of the right epididymis, with a hard nodule $\frac{1}{2}$ in. in diameter in the globus minor. The vas was thickened up to the level

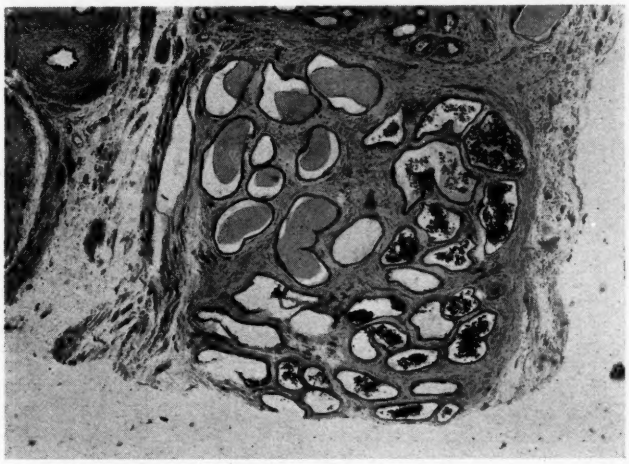


FIG. 573.—A section from the epididymis of *Case* 3, showing dilated tubules with flattened epithelium and retained secretions. (× 8.)

of the superficial inguinal ring. There was a nodule, $\frac{1}{2}$ in. across, in the right seminal vesicle; the prostate felt normal. A centrifuged specimen of urine showed 10 leucocytes and 2 erythrocytes to each $\frac{1}{6}$-in. field, and culture gave a scanty growth of long-chained streptococci.

AT OPERATION.—Epididymectomy was performed. The seminiferous tubules were dilated, with flattened epithelium; they held retained secretions and some macrophages enclosing Reinicke's crystals (*Fig.* 573). In the interstitial tissues were granulomatous areas

containing centres of calcification and macrophages with crystals. These areas were more marked in the wall of the vas, of which the epithelium was normal. There was no evidence of tuberculosis, and the appearances were thought to be due to a low-grade inflammatory process caused by the retained secretions.

Case 4.—

HISTORY.—A coach painter, aged 38, found a small and painless swelling on his left testicle one month before admission. It had gradually enlarged during the interval. There had been no urethral discharge and no abnormality of micturition. There was no history of venereal disease, and no personal or family history of tuberculosis.

ON EXAMINATION.—The left epididymis was represented by a hard, craggy mass, $1\frac{1}{2} + \frac{3}{4}$ in. It was more obvious at the lower pole. There was no tenderness, and the cord and vas were normal. The prostate and vesicles were healthy. The urine was sterile and without albumin or abnormality of the cells. The lungs appeared to be healthy on radiography.

AT OPERATION.—Orchidectomy was carried out. The globus minor was firmly adherent to the scrotum, a small area of which was excised. A part of the epididymis showed extensive fibrosis containing many areas of chronic inflammatory cells, with plasma cells predominating. The vas and the tubules of the epididymis contained frank pus. No tubercles and no caseation were seen. Ziehl-Neelsen and Gram staining did not reveal any identifiable bacteria.

Case 5.—

HISTORY.—A cinema operator, aged 34, had a clinical history extending over one year nine months. While at work he had felt severe pain in both groins, with nausea and an urge to pass urine; on doing so a spurt of blood came first, followed by clear urine that was painful to pass. Then the pain disappeared.

Six months later he felt sick a quarter of an hour after severe exertion, and went to bed. An hour later he was awakened by severe pain in the right testis, which was swollen and tender. This condition lasted in its severity for three days, but all symptoms had disappeared by the end of a fortnight.

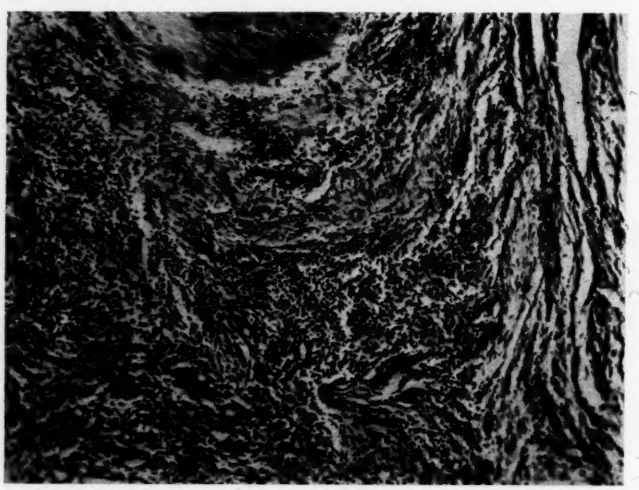


FIG. 574.—A granulomatous area from the epididymis of *Case* 5. (× 64.)

Three months after this the symptoms recurred while at work, still on the right side. They were less severe than in the earlier attack and subsided entirely in three days.

One month before admission he had another attack, again when working. This time an urgent desire to micturate led to the passage of a little bright blood at the beginning of the stream, on one occasion, to be followed by severe pain in the groins, numbness in the legs, nausea, and collapse. His left testis swelled, but not so much as the right had on former occasions. There had been no increased frequency of micturition.

ON EXAMINATION.—There was enlargement and great tenderness of the left testis, affecting the epididymis principally and the body of the testis slightly; there was also a firm, craggy nodule in the globus minor. The right lobe of the prostate contained an irregularity. The urinary examination and radiographs of the chest failed to show any abnormality.

AT OPERATION.—Orchidectomy was performed. An area of hard tissue in the epididymis was found to have subacute inflammatory changes suggesting a resolving acute inflammation. There was no caseation and no histological evidence of tuberculosis. (*Fig.* 574.)

Case 6.—

HISTORY.—A house porter, aged 54, knocked the left side of his scrotum eleven months before admission. It was painful for one day. A month later a painless swelling appeared in the left side of the scrotum, gradually becoming larger. Five months before admission a hydrocele was tapped, but became a hæmatocele. Two months after this the swelling had disappeared except for a hard, craggy mass, 1¼ in. in diameter, above the testis. There had been no micturition symptoms, and there was no history of venereal disease.

AT OPERATION.—On exploration a small hydrocele was found in the tunica vaginalis and there were hard areas in the globus major of the epididymis, which was thickened generally, and also in the cord just above that level. Incision of the globus major suggested that the nodule was breaking down, so that orchidectomy was carried out.

The seminiferous tubules were atrophied and surrounded by fibrous tissue. There was no spermatogenesis and the epithelium had undergone squamous metaplasia in places. The interstitial cells showed up clearly in the surrounding fibrosis. The walls of the vas were thickened and its epithelium was atrophied. No evidence of tuberculosis was found.

Case 7.—

HISTORY.—An engineer, aged 52, was awakened one morning three weeks before admission by pain in his left groin, and noticed that the testicle on that side was swollen. He felt certain that no swelling had been there before. These symptoms continued, and a week later they both appeared on the right side also, though to a lesser degree. Following this the pain became worse—a constant aching without radiation. During the last two weeks there had been a little increased frequency of micturition, three-hourly by day and once or

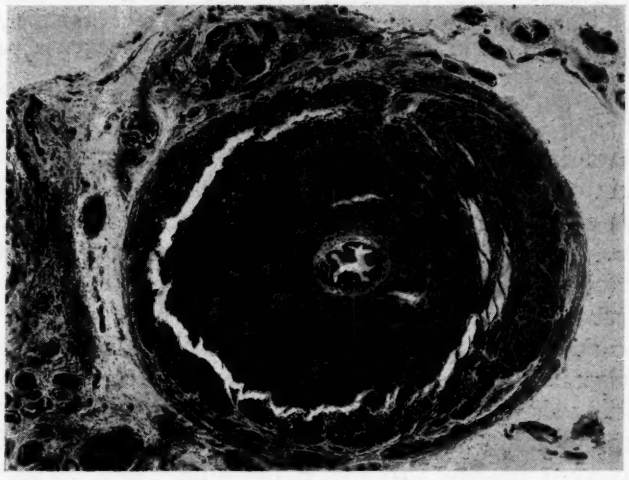


FIG. 575.—The vas of *Case* 7, showing muscular hypertrophy. (× 12.)

twice at night. There was no history of gonorrhœa or syphilis, but a painless thoracic kyphosis had been present for at least ten years.

ON EXAMINATION.—Both testicles were normal, but both epididymes were enlarged, hard, and craggy. Both vasa were distinctly beaded. The right spermatic cord was tender at the superficial inguinal ring. The right side of the prostate was slightly enlarged, but smooth, and the right seminal vesicle was also enlarged and was firmer than normal. The

urine was sterile and acid, with no abnormality of the cells. A blood-count, a Wassermann reaction, an intravenous pyelography, and plain radiographs of the spine, lungs, and pituitary fossa showed no relevant abnormality.

AT OPERATION.—Bilateral epididymectomy was performed. The enlargement and irregularity of the epididymes was more marked towards the lower poles. The beading of

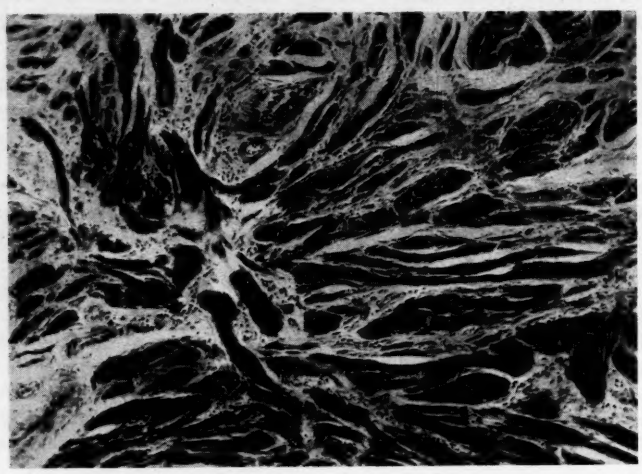


FIG. 576.—An area in the epididymis of the same patient, showing the increase of plain muscle. (× 56.)

the vasa was well developed, and they were also generally thickened and abnormally adherent to the other components of the cord. The testes were normal.

Both vasa and epididymes showed a remarkable increase of plain muscle, the thickening of the vasa being entirely due to this (*Figs.* 575, 576). Obliterative endarteritis was seen in a few vessels. There was no evidence of tuberculosis, nor was there any fibrosis or cellular infiltration to be found in any part of the sections to suggest a past infection.

AETIOLOGY

These 7 cases do not form a collection with a single cause. It is not easy to explain the origin of some of the conditions seen, and the histological examination necessarily plays an important part in arriving at conclusions that are sometimes merely tentative. They may be separated into three groups, those due to: (1) Inflammation; (2) Obstruction; and (3) Vascular conditions. Of these divisions, inflammation probably accounts for 4 cases in the present series.

1. Inflammation.—The principal type of inflammation to be considered is a low-grade pyogenic infection. This is the probable explanation of *Cases* 1, 2, and 4, and possibly also of *Case* 5.

Although the infection may theoretically reach the epididymis from the blood, some features make it unlikely that this is the usual route. The lesion is always in the epididymis and not in the body of the testis; the globus minor is either diseased alone or is the region most diseased; in some cases the condition is bilateral, the two sides being affected on the same or on different occasions. These points are not to be explained plausibly on a theory of hæmatogenous infection, and are much more consistent with spread along the vas deferens. The vas itself offers two possible routes. First, the organisms might travel along the lymphatics in its wall; this may take place when there is a focus in the prostate or seminal

vesicles, and certainly irregularities were found in the internal genitalia of some of these patients, though by no means in all. Secondly, the infection might be carried along the lumen of the vas in urine. Organisms may have reached the urine by excretion from the kidney, or they may have entered the urinary passsage directly from any focus that might exist in the prostate or vesicles. That such retrograde passage of urine can take place is now well established. It may sometimes be seen at vasotomy, and has been made the basis of an explanation, by C. A. Wells, of tuberculous infection of the epididymis. It is quite possible that while a man is straining, as when doing heavy work, a little urine may be forced past the vesical sphincter, though without incontinence because the sphincter urethræ membranaceæ is still acting. Thus, with urine under some pressure in the posterior urethra and yet unable to pass to the exterior, it is easy to imagine a few drops being driven into the ejaculatory ducts and so into the vasa. The history of *Case* 5 would fit in well with such an explanation, as it suggests the sudden passage of an irritant along the vas, and this on several occasions. The drops of blood at the beginning of micturition in two attacks may have been due to the passage of small calculi, or to some congestion or structural abnormality in the posterior urethra. Cystoscopy did not show any stones in the bladder, but posterior urethroscopy was not performed.

It is to be noted that in some examples the enlargement of the epididymis is painless and without clinical evidence of disease in the urine, prostate, or vesicles, and without any history of general disease or focal infection. Yet in these cases the histological features point quite definitely to a pyogenic origin of low virulence.

The inflammation may not always be due to infection. It is possible that the retrojection of sterile urine may lead to an aseptic inflammatory reaction in some cases, and evidence will be produced in the next section that retained secretions can also act as a mild irritant.

2. Obstruction.—Two patients of the series had indirect evidence of obstruction at some point along the vas or ejaculatory duct.

Case 7 was most interesting. The sections contained no support for an inflammatory origin, and the outstanding feature was the hypertrophy of plain muscle in the vasa and epididymes. It is impossible to believe that this muscular hypertrophy was an isolated phenomena of the nature of an innocent tumour, yet recent and bilateral, and there was no evidence that the man was acromegalic. This leaves as the most likely explanation a hypertrophy following some obstruction. The enlargement and firmness of the right seminal vesicle may be contributory evidence, suggesting a possible lesion that might have given rise to blockage of the duct.

The histology of the epididymis of *Case* 3 had not the features of an infection, in spite of the fact that the urine contained an excess of leucocytes and the *Str. fæcalis* was grown from it. The macrophages and granulomatous areas are characteristics of a mild inflammatory process. The presence of Reinicke's crystals, particularly within the macrophages, may be a clue to the irritant, and suggests that it was the retained secretions. The dilatation and flattening of the epithelium in the seminiferous tubules indicates an obstructive cause for the retention, whether due to an occlusion near the ejaculatory duct, where there was a palpable nodule in the seminal vesicle, or to one near the epididymis, a possible late result of his gonorrhœa.

3. Vascular Causes.—Vascular changes may undoubtedly give rise to conditions resembling tuberculous epididymitis in their physical signs.

In an earlier paper[1] I have discussed the spontaneous occurrence of thrombosis in the pampiniform plexus, describing 2 cases that were established by orchidectomy and pathological examination. At present this accident must be considered uncommon, but it is certainly not rare, and it is probable that it usually goes unrecognized. During the period from which this series has been drawn 2 more

FIG. 577.—Spontaneous thrombosis of the pampiniform plexus. A section from the spermatic cord of a man whose condition had begun five weeks earlier. (× 12.)

cases of the spontaneous type have been seen, and have subsided with conservative treatment. There were other doubtful examples, but not sufficiently definite to be included in an account of the condition. (*Fig.* 577.)

Case 6 does not fit into the categories of infection or duct obstruction. From the history and from the position of the residual swelling above the testicle the probable explanation is a traumatic thrombosis low in the pampiniform plexus, with a hydrocele resulting from the impaired venous drainage, the other changes also following upon the vascular disturbance.

DISCUSSION

Whether the suggested explanations are true or not is less important than the fact that chronic non-tuberculous disease of the epididymis is quite common, even when cases due to some obvious infection have been excluded.

The majority of such conditions will subside in the course of time, or they will improve up to a certain point and then persist as a residual nodule. *Case* 1 of this series, with a small abscess cavity, might have gone on to absorption and fibrosis under conservative measures, but operation was a reasonable and more direct treatment. *Case* 3 may also have needed operation, as his swelling was becoming larger and softer. With the remaining five patients surgery might have been avoided, although it cannot be stated categorically that all would have subsided without operation. It is tolerably clear that excision was unnecessary for *Case* 6.

The problem may be approached in a different way. During the period from which these patients have been drawn there have been several examples of the condition among out-patients. Three men were investigated, annotated, and followed up with particular care, and their lesions underwent complete resolution in nine weeks, three months, and four months. These were in addition to the 2 cases, already mentioned, of spontaneous thrombosis of the pampiniform plexus, with its similar clinical picture.

When no operation is performed, or when excised material is not submitted to careful microscopical examination, such cases will continue to be looked on as tuberculous. Their inclusion in any reported series will not only improve the apparent prognosis of tuberculous epididymitis, but will also lessen the apparent association of genital with urinary tuberculosis. I suspect that the type of tuberculous epididymitis described as having an acute or subacute onset and later settling down to a chronic course, contains a considerable proportion of this kind of disease. Also it is desirable that specific remedies, such as tuberculin, should not be thought to have produced cures that would have come about without their help.

Thus, whenever possible tuberculous cases should be separated from those due to other causes. In the first place, a careful assessment of the history and physical signs may make one suspect that the disease is not a straightforward example of tuberculosis. A non-tuberculous enlargement is often less hard and less craggy than a tuberculous one, and a venous thrombosis may sometimes be palpated separately from the epididymis, or as a mass extending from the globus major up into the spermatic cord. It should be axiomatic that a diagnosis of tuberculous epididymitis involves a complete examination of the patient, particularly the lungs and urine, and probably also an intravenous pyelography. The figures recently given by C. A. Wells[2] will serve to show how commonly urinary and genital tuberculosis are associated or consecutive diseases. Should there be no suggestion of tuberculosis elsewhere than in the epididymis, a sceptical attitude may be adopted for a while. It is hardly justifiable to diagnose tuberculous epididymitis at one of the patient's early attendances merely because one can find no reason to think that the lesion is due to anything else, and in the absence of positive evidence pointing to tuberculosis. Lesions in the prostate and vesicles may occur in either type of disease, but if gross and unassociated with a history of definite urinary or urethral infection they may be considered as more likely to indicate tuberculous disease. Thickening of the vas is of little help, but beading would suggest tuberculosis, although it was well developed in *Case* 7 of this series. Attachment to the skin of the scrotum also points to tuberculosis, though this too was found in one patient (*Case* 4).

When the diagnosis remains doubtful and the epididymitis is not certainly tuberculous, the patient should be examined at intervals over a period of three months, during which most of the other conditions will subside. He may wear a suspensory bandage, but treatment with tuberculin should be avoided, as it will only confuse the mental picture. Such a course can lead to little harm, and many operations might be avoided. If the condition advances or declares itself clearly tuberculous during this time, appropriate treatment can be started. The only disease which would be harmed by a period of observation is the rare carcinoma of the epididymis. I have seen reticulosarcoma affecting the epididymes give

physical signs exactly resembling tuberculosis, but as the patient had generalized reticulosis the case is of no practical importance in this way. Enlargements of the body of the testis are quite unsuitable for prolonged observation, but clinical examination will have excluded an origin of the swelling from this site.

Should there be subsidence and then recurrent exacerbations of the epididymitis, any focus present in the prostate or vesicles will need active treatment to prevent the troublesome attacks from continuing. Occasionally (*Case* 1) the condition progresses instead of subsiding, so that epididymectomy, or even orchidectomy, may be needed.

CONCLUSIONS

Chronic disease of the epididymis is often not tuberculous.

A diagnosis of tuberculous epididymitis should be based on some positive evidence in its favour, and not merely on the absence of evidence ruling it out.

Conditions of doubtful origin should be watched at intervals for three months, during which most non-tuberculous lesions will subside.

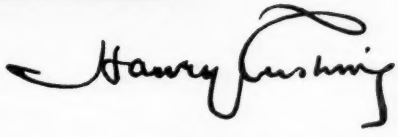
I wish to thank those members of the staff of St. Bartholomew's Hospital who have allowed me to make use of their cases.

REFERENCES

[1] McGavin, D., *Lancet*, 1955, ii, 368.
[2] Wells, C. A., *Brit. Jour. Urol.*, 1938, x, 114.

DR. HARVEY CUSHING

DR. CUSHING'S first contribution to this JOURNAL was in 1918 on the subject of "A Study of a Series of Wounds Involving the Brain and its Enveloping Structures". He was then the Director of the United States Army Base Hospital, British Expeditionary Force. Since then we have had various articles by his pupils, Dott, Bailey, Jefferson, and others. We have all been conscious of the profound and beneficent influence which Dr. Harvey Cushing has exercised over British Surgery.



In fact it may safely be said that the majority of British surgical clinics concerned with brain surgery have been inspired by his work and directed by surgeons who have been to Boston to learn his methods. In 1930 Dr. Cushing delivered the Lister Memorial Lecture, having already, in 1913, been elected an Honorary Fellow of the Royal College of Surgeons. We are delighted to have this opportunity of paying a tribute to him and his work on the occasion of the seventieth anniversary of his birthday. By a happy coincidence we are able to publish as a fitting tribute the most complete article which has yet appeared on his work on pituitary tumours.

May he live long to enjoy the fruits of his labours and the esteem of his colleagues, among whom none are more ardent than his British admirers.

THE presentation of the paper which follows is a fitting tribute to one who seems destined to leave an indelible impression on the history of medicine—Harvey Cushing. Its publication marks the seventieth birthday of one who has remained for a lifetime a student of the subjects that he has made his own. It is very proper that the paper should be concerned with the after-histories of sufferers from tumours of the pituitary. For when Harvey Cushing, over thirty years ago, commenced their study and their treatment he was unlocking a door that led to fields wider than he could have known. He held the key to endocrinology. And though as a practical surgeon the welfare of his patients was his first consideration, as this follow-up testifies, he set an example which will not be forgotten in the extraction of scientific minutiæ that led eventually to a synthesis.

The story of the pituitary is not yet complete, but the work of Harvey Cushing has accelerated progress in one of those inspired bursts of speed that characterize great epochs in the history of disease. This alone would be an enviable monument.

G. J.

THE PITUITARY ADENOMATA

A FOLLOW-UP STUDY OF THE SURGICAL RESULTS IN 338 CASES* (DR. HARVEY CUSHING'S SERIES)

By W. R. HENDERSON, Leeds

SUMMARY OF CONTENTS

I. Introduction.
Clinical Material.
Pathology.
Operative Procedures Employed.
II. The Chromophobe Adenomata.
A. The Surgical Mortality Statistics.
B. The Early Results of Operation.
1. Bitemporal Hemianopia.
2. Homonymous Hemianopia.
3. One Eye Blind and the Other Affected.
4. Central Scotoma or Inferior Quadrantal Defects.
5. Only One Eye Affected.
6. Bilateral Blindness.
7. Normal Vision.
C. The Late Results of Operation.
D. X-ray Treatment (Pre-operative *v.* Post-operative).
E. Remarks on the Treatment of Chromophobe Adenomata.
1. Operation *v.* X-ray Therapy.
2. Transfrontal *v.* Transsphenoidal Operations.
F. The Treatment of Recurrences.
G. Cysts.
1. Intrasellar.
2. Intracerebral.
H. Post-operative Clots.
1. Extradural.
2. Suprasellar.
3. Incidence of Clot Formation.
I. Nasopharyngeal Extensions.
J. Intracranial Extensions.
The Clinical Course in Advanced Cases.
III. The Acidophil Adenomata.
A. Post-operative Mortality.
B. The Early Results.
C. The Late Results.
IV. The Adenocarcinomata.
The Two Clinical Varieties.
V. Conclusion.
VI. Summary.

* From the Brain Tumour Registry, Yale University School of Medicine, New Haven, U.S.A.

I. INTRODUCTION

THIS paper is a report of the early and late surgical results of Dr. Harvey Cushing's Brigham Hospital series of histologically verified pituitary adenomata. It is an expansion of the survey that was made when I had the privilege of working in Dr. Cushing's clinic at the Peter Bent Brigham Hospital in Boston during 1929–1931. At that time I reviewed, at Dr. Cushing's suggestion, the operative results during a ten-year period (1921–1931), particularly from the standpoint of the surgical mortality statistics and of the improvement in vision following operation. These figures, which covered the period during which the trans-sphenoidal operation was being superseded by the transfrontal operation, with increased success in many cases, have already been quoted briefly (1932),[10] but were not published in detail.

Dr. Cushing has generously allowed me to use for the purpose of the present report the entire Brigham Hospital series, which covers a twenty-year period (1913–1932) and totals 338 cases.* This should be the more valuable because it has been possible to make a follow-up study of the patients, all of whom were operated on more than five years ago. I could not have done this without the ever-willing co-operation and assistance of Dr. Louise Eisenhardt, formerly of the Peter Bent Brigham Hospital and now in charge of the Brain Tumour Registry at New Haven, through which agency the great majority of the patients continue to be followed. I was also fortunate in having the opportunity of examining personally a considerable number of the patients when I visited New Haven in the Autumn of 1936 to assemble the preliminary data for this paper.

Other reports have been made from the records in the Registry by Dr. William P. Van Wagenen (1934)[26] and by Professor Hugh Cairns (1936),[3] both of whom reviewed the late results of a year's series of patients with intracranial tumours of all kinds, eight or nine years after operation. The present report differs from theirs in that it is a study of patients with only one kind of tumour, but over a much longer period of time.

CLINICAL MATERIAL

The number of cases, arranged according to the histological type of the tumour, is shown in *Table I.* The series is restricted to adenomata of the anterior lobe of the pituitary body itself. Other tumours in the same region, some of which

Table I.—NUMBER OF VERIFIED PITUITARY TUMOURS DURING THE TWENTY YEARS, 1913–32

Adenomata:	
Chromophobe	260
Acidophil	67
Adenocarcinomata	11
Total	338

may occupy and enlarge the sella turcica (e.g., craniopharyngioma), are not included, although they are sometimes grouped with the adenomata under the comprehensive term of ' pituitary tumours ' used in its wider sense. Many of the

* The discrepancy between Dr. Henderson's figures and the 389 adenomata in Dr. Cushing's series is accounted for by the fact that the cases prior to 1912, together with those not surgically treated, have been excluded in this review.—L. E.

earlier writings on pituitary disorders dealt with a variety of tumours, some of which were extrasellar in origin and affected the pituitary body only secondarily, but such a practice is apt to lead to confusion.

This paper is concerned primarily with the surgical results. Many of the patients, however, received X-ray treatment in addition to operation, and an attempt will be made to evaluate the relative effects of these two forms of treatment. It was the practice in the clinic to operate on all patients suspected of having a chromophobe adenoma, and with rare exceptions, which remain of course histologically unproved, they were never treated by X-ray therapy alone. The results of treatment by operation alone and by X-ray therapy alone cannot, therefore, be compared from this series.

As regards the acidophil adenomata, the group of 67 cases does not represent all the patients with acromegaly who entered the clinic. Many patients, mostly with small adenomata, received X-ray treatment only. As their tumours remain surgically unverified, they have not been included in this study, although the presence of an acidophil adenoma may be taken for granted.

The incidence of pituitary adenomata in Dr. Cushing's collection of 2,023 histologically verified intracranial tumours (1932)[10] is 17·8 per cent, which is considerably higher than in most other clinics; such a high incidence is, no doubt, due to his special interest in pituitary disorders. It is not easy to estimate the true relative frequency of chromophobe and acidophil adenomata, but the latter are unquestionably less common. The ratio of chromophobe to acidophil, which is 4 : 1 in this series, is about the same as reported from other clinics.

PATHOLOGY

Histologically, adenomata of the pituitary body are of three varieties—chromophobe, acidophil, and basophil; the far less common adenocarcinomata which tend to infiltrate surrounding structures appear to be composed of chromophobe elements, but they are in need of further study. From a surgical standpoint, the chromophobe adenomata are by far the most important of the four types. They are composed of non-granular cells which, so far as is known, have no secretory activity. The secondary constitutional disturbances of pituitary insufficiency, due to compression of the normal glandular tissue, are so inconstant and unimportant that the disorder is not likely to be recognized until the tumour is large enough to compress the optic nerves, chiasma, or tracts. Treatment is, therefore, a mechanical problem and must be evaluated chiefly by its effect in restoring vision.

The adenoma associated with acromegalic overgrowth is composed of coarsely granular acidophil cells, as was shown by Bailey and Davidoff (1925)[2] and by Dott and Bailey (1925).[14] Its constitutional effects are striking and are often the only complaints. The adenoma thus reveals itself long before it is large enough to implicate the chiasma or even distend the sella. Treatment, therefore, is frequently more concerned with controlling the serious general consequences of the excessive secretion than with local mechanical disturbances.

Dott and Bailey,[14] in their clinical and pathological study of 162 cases of pituitary tumour, separated an intermediary group of 13 cases of 'mixed' adenomata. These tumours are characterized histologically by the presence of

sparse, acidophil granules, often disposed around the periphery of the cells, and clinically by the mixture of signs of hypopituitarism with recognizable skeletal traces of pre-existing hyperpituitarism, which Bailey and Cushing (1928)[1] termed 'fugitive' acromegaly. These mixed or transitional cases may assume surgical importance by virtue of the large size which the tumours frequently attain; the 32 examples in the present series have, for the purpose of this paper, been included with the chromophobe adenomata.

The third type of adenoma, the basophil adenoma, has only recently acquired, since Cushing's publication in 1932,[11] widespread clinical and pathological interest. It apparently, however, rarely attains a large size, and remains, as yet, of no great surgical importance.

The adenocarcinomata, of which there are 11 examples, represent only about 3 per cent of pituitary tumours.

From the surgical standpoint, it is essential, before discussing the aim and the scope of the operations, to refer briefly to the gross pathology of pituitary adenomata, and especially to the direction of their growth in relation to the important structures at the base of the brain. The tumour at an early stage, before there is any noticeable enlargement of the pituitary body, may consist merely of a hyperplasia of its particular variety of cells scattered diffusely through the anterior lobe; but in most instances it is a definitely adenomatous formation which compresses the remainder of the gland and so forms a small circumvented nodule. Because of their characteristic constitutional effects, the acidophil and the basophil adenomata are frequently diagnosed at this stage, before there is any enlargement of the sella or disturbance of vision.

An adenoma, of any variety whatsoever, may in the course of its growth serve to expand the sella and even to protrude beyond its confines. The intrasellar portion of a large adenoma has no capsule other than that made by the compressed remains of the pituitary body, which may be flattened into a thin shell and eventually destroyed. In cases with a reasonably early clinical syndrome, the growth protrudes just sufficiently above the level of the sella to produce optic or chiasmal compression. Its rounded dome is covered by the stretched diaphragma sellæ and the only serious symptom is impaired vision.

As the adenoma continues to expand it eventually bursts through the dural capsule in one or more of several directions:

1. The tumour may extend downwards to fill the sphenoidal air cells, and occasionally it even breaks through the base of the skull into the roof of the nasopharynx, where it may form a large mass.

2. The tumour may break out through a narrow opening just above the side of the sella, without seriously affecting the optic chiasma, and expand laterally into the temporal lobe, where it is apt to remain quiescent until it has reached a large size.

3. It may continue to grow upwards above the sella, eventually forming a massive intracerebral extension which obliterates the third ventricle and displaces the basal ganglia or branches out into the frontal lobe.

4. In other cases only a small nodule of tumour is extruded through a fenestration in a malformed diaphragma sellæ and quickly impinges upon an optic nerve, causing loss of vision in one eye; or the nodule may escape through the normal opening in the diaphragma by tracking up alongside the pituitary stalk,

and so come to lie concealed under the chiasma, where it is very apt to escape detection during the carrying out of a transfrontal exploration. These small extrusions, although extrasellar, are not large enough to be regarded as intracranial extensions.

Whether the tumour is likely to grow chiefly downwards, destroying the bone, or upwards through the dura, forming either a small suprasellar extrusion or a large intracranial extension, depends upon several factors which are not wholly understood, such as the relative strength of the diaphragma sellæ and the presence or absence of a strong bony septum in the sphenoidal sinus. It is now well recognized that in some cases the growth of the tumour is entirely upwards, so that it affects vision without producing any enlargement of the sella—the so-called suprasellar adenoma.[9] The most important criterion in the diagnosis of a pituitary (chromophobe) tumour is, therefore, a progressive defect in the visual fields, whether or not there also happens to be an expanded sella.

Any tumour that has produced visual disturbances may be regarded, in an anatomical sense, as having an intracranial extension in that it usually has to extend upwards for a distance of 1 or 2 cm. above the normal level of the diaphragma sellæ before seriously implicating the chiasma. From the clinical standpoint, however, only the massive expansions into the substance of the brain should be called intracranial extensions.

Once an adenoma has burst through the dural framework of the sella into the cranial chamber, it is delimited by a smooth, well-defined, though soft, capsular condensation of its own substance. This prevents the tumour becoming adherent to or infiltrating the displaced optic structures and the surrounding brain, and makes it easily separable from them at operation. But it is important to note that some intracranial extensions, particularly of acidophil adenomata, are apt to surround the more fixed structures in the immediate vicinity of the sella, such as the carotid artery and perhaps the oculomotor group of nerves, without, however, necessarily affecting their function.

It will be apparent from this brief outline of the pathology of pituitary adenoma that the approach and the scope of operation must vary in certain cases, and that in some instances X-ray therapy may be preferable to operation. When there is no definite enlargement of the pituitary body it is difficult to locate and remove a small acidophil or basophil adenoma for the relief of severe constitutional symptoms, unless it has formed a marginal nodule, without taking away at the same time a considerable portion of the normal glandular tissue; X-ray treatment may be effective in adenomata of this type. In the majority of chromophobe adenomata, the bulk of the tumour may be reduced by intracapsular excavation, which allows the remaining capsule to collapse into the sella; this is usually followed by good recovery of vision provided the compression is relieved before permanent optic atrophy has supervened. In the more advanced cases with symptoms of intracranial extension, the surgical approach naturally depends upon its exact position as described above. Ventriculography may be required to determine this accurately. The extrasellar portion of the tumour does not become adherent to surrounding tissues, and so it may be possible to effect its clean removal. No attempt should be made to remove the deeper portions of the capsule which may have surrounded important vessels in the interpeduncular region or have become adherent to the dura lining the sella.

OPERATIVE PROCEDURES EMPLOYED

The story of the evolution of the fairly well standardized, modern pituitary operations has been very fully reviewed by Heuer (1931).[18] It is interesting to note that the first authentic successful partial tumour removal was made by the extracranial transsphenoidal route, after an extensive resection of nasal structures, by Schloffer in 1907, only six years before the beginning of this series. The early complicated procedures were soon simplified, and before the publication in 1912 of his monograph,[5] Cushing had already evolved the transsphenoidal operation, long utilized in his clinic. Others advocated an intracranial exposure from the side, but the mortality of these procedures was considerably higher than that for the transsphenoidal route. In later years both methods have been almost completely abandoned in favour of the more radical, and comparatively safe, transfrontal operation.

A description of the operations does not come within the scope of this report, but it may be convenient to outline briefly the aim and the limitations of the procedures employed, indicating the complications that may occur and certain technical details which Dr. Cushing has stressed at various times.

1. The Transsphenoidal Operation.—A large, ballooned sella was in the early days regarded as an essential sign of a pituitary tumour, and the radiological demonstration of its extension downwards towards the nasopharynx naturally led to the development of the transsphenoidal operation. This extracranial approach was used by Dr. Cushing as the routine procedure for many years, at a time when intracranial explorations were much less safe than they are nowadays. The steps of the operation are illustrated and described in detail elsewhere.[6] The line of approach and the average amount of tissue removed from a solid tumour is shown in *Fig.* 578.

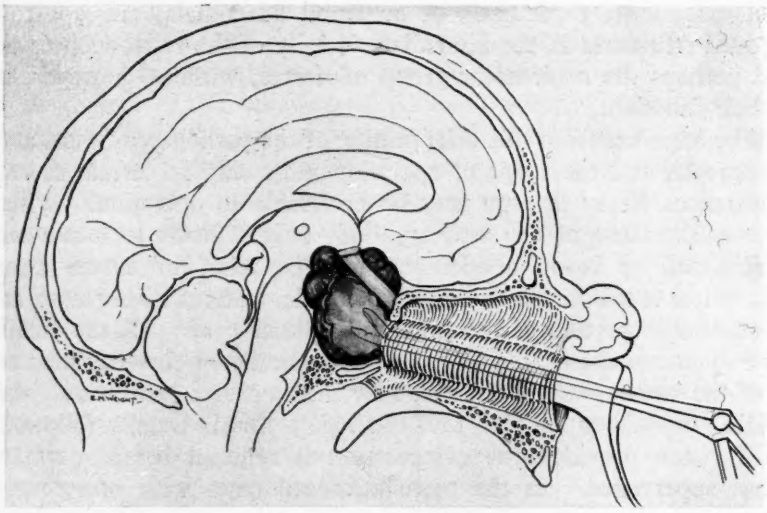


FIG. 578.—Schematic representation of the extracranial transsphenoidal approach to a pituitary adenoma.

Briefly, the operation consists of making a submucous resection of the lower half of the nasal septum through a concealed sublabial incision in the mucous membrane above the incisor teeth. The lower turbinates are temporarily flattened by dilating plugs, but are not removed. It is usually possible to avoid tearing through the mucous membrane during its separation from each side of the septum, so that the approach is by way of the nose, but

does not actually enter the nasal cavities. The submucous dissection is carried back to the sphenoidal air sinus, the anterior wall of which is punched away. The conditions found within the sphenoidal cells vary in different cases; in some, the bulging depressed floor of the sella is still intact, though reduced to a thin shell of bone; in others, the tumour has broken through into the sphenoidal sinus, which in the more advanced cases is filled with tumour; and in rare instances the tumour has already eroded through the bone into the nasopharynx.

If the dural covering of the tumour is still intact, it is incised, whereupon the adenomatous tissue usually escapes spontaneously unless it is very firm and tough, when it has to be removed with a curette or rongeurs. This allows the tumour to sink downwards and relieves the pressure on the chiasma. Whether the operation is limited to a mere sellar decompression and fragmentary removal of the tumour, or whether the intrasellar mass is radically excavated, must depend upon circumstances such as the consistency of the tumour and the possibility of sepsis if the mucosa has been badly torn. When the tumour is very tough it is rarely possible to remove more than a few fragments.

In suitable cases a considerable quantity of the lower and central portion of the tumour is cored out, but a complete clearance is not attempted because of the difficulty of estimating how much can be taken out without suddenly displacing its upper end and possibly starting a cerebrospinal fluid leakage. In the average favourable case probably one-third or even two-thirds of the tumour is removed, and, as the results will show, this is sometimes sufficient to prevent any recurrence of symptoms and the growth of the tumour is apparently arrested. It is not clear why this should be so unless the scar formation in the blood-filled cavity initiates a spreading fibrosis which interferes with the vascularity and nutrition of the remaining tumour.

The approach is somewhat cramped and it allows only a restricted view of the lower end of the tumour, even when the sella is large. The operation is more difficult when there is a well-developed bony septum in the sphenoidal cells. A cystic tumour is often regarded as most suitable for the transsphenoidal operation, but it is unfortunately impossible to foretell whether the adenoma will be firm, soft, or cystic. In any event, it is doubtful whether the transsphenoidal is preferable to the transfrontal approach for a cystic tumour owing to persistent refilling of the cyst in some cases. It is true that a most dramatic immediate improvement in vision may follow the collapse of a cyst or the evacuation of a very soft tumour from below, but a more fragmentary removal of a solid tumour or even a simple sellar decompression sometimes gives just as good a final result, although it is more gradual.

It is sometimes stated that the removal of the sellar floor makes it easier for the tumour to extend downwards and so lessen the tendency for it to burst the diaphragma sellæ and invade the cranial chamber. While the tumour may thus be encouraged to extend into the sphenoidal air cells, it is unlikely that any appreciable quantity of it escapes into the nasopharynx, as the opening is soon closed by scar tissue.

Although this approach is no longer employed as a routine, it still has definite advantages for aged patients or when the general condition of the patient is poor. It is most useful, perhaps, as a palliative decompression when the sella is very large and the tumour may be presumed to have a large upward extension; in such cases the patient's condition is often poor, and in acromegaly the frontal air sinus is apt to be large, which makes the transfrontal approach difficult. As regards cases of chromophobe adenoma, it will be suggested later that the transsphenoidal operation is preferable to any other in the presence of certain types of visual field defects which are believed to indicate that the tumour is extending upwards behind the chiasma.

2. The Transfrontal Operation.—The adoption of the transfrontal operation (*Fig.* 579) as the routine procedure during later years arose out of the experience that had been gained from chiasmal explorations in patients with unexplained bitemporal hemianopia (and a normal sella), many of whom were found to have removable suprasellar tumours (e.g., meningioma, adenoma). The visual recovery seemed to be more complete than was customarily obtained after transsphenoidal operations, and experience soon showed the importance of removing the supradiaphragmatic extrusions which are commonly present around the optic nerves. The intracranial approach was eventually used, therefore, for nearly all pituitary tumours, irrespective of whether the growth of the tumour was chiefly upwards (with a small sella), or downwards as well (with a large sella).

This operation was usually performed under local anæsthesia, which was in general use in the clinic for all intracranial procedures, after a preliminary injection of morphine (10 mg.) and scopolamine (0·3 mg.).

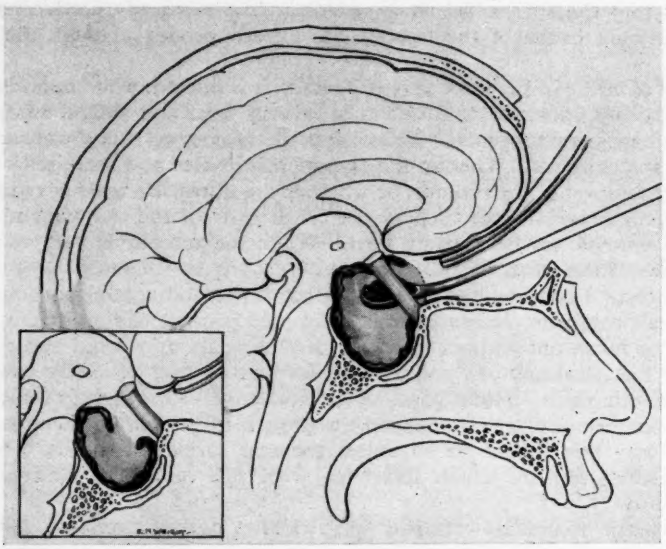


FIG. 579.—Schematic representation of the intracranial transfrontal approach to a pituitary adenoma through the prechiasmal space after elevating the frontal lobe. After thorough excavation the tumour capsule is withdrawn from the optic nerves and chiasma (cf. inset).

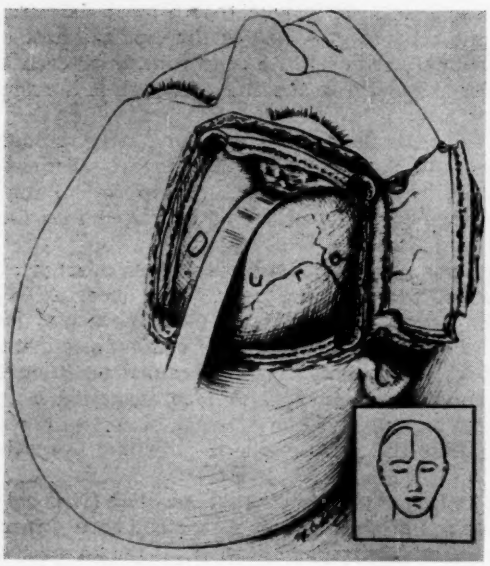


FIG. 580.—Showing the incision (inset), position of flap, and elevation of dura from the orbital plate.

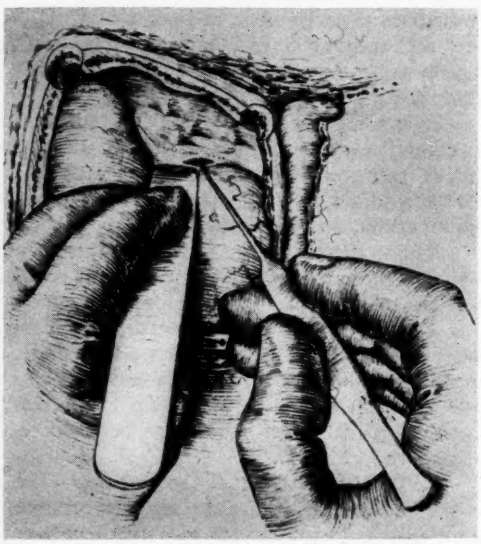


FIG. 581.—Opening the dura at its line of attachment to the sphenoidal ridge.

Dr. Cushing prefers to approach the chiasmal region from directly in front, close to the midline, through a small osteoplastic flap (*Fig.* 580). The scar is hardly noticeable if the vertical incision is made exactly in the midline and the wound is carefully closed in layers,

the sutures being removed in forty-eight hours; many surgeons, however, prefer to avoid the midline wound by using a single coronal incision behind the hair line and reflecting the scalp of the forehead downwards to the supra-orbital margins. The bone is cut just on the midline and as low in front as the frontal air sinus will allow; it is reflected with the scalp as an osteoplastic flap. Very occasionally the frontal sinus is accidentally cut across, but if the opening is covered immediately with a piece of fascia there is very little risk of infection.

As regards the side of operation, Dr. Cushing chose to approach these midline tumours from the right side, irrespective of whether the right eye had the better or the worse vision, in the belief that a right-handed surgeon can make the delicate manipulations in the neighbourhood of the optic nerves more easily from the right side. It may be noted however, that there is considerable difference of opinion among surgeons as to which is the better side for approaching pituitary tumours; some prefer to go on the side of the better eye so that the good optic nerve can be more easily seen and protected during the manipulations, whilst others have held that it is better to operate on the side of the more seriously affected (or blind) eye in case it should be thought advisable to improve access by cutting the optic nerve, which may be necessary when the chiasma is prefixed (an uncommon occurrence). In this series an optic nerve was sacrificed in only the most exceptional circumstances.

The extradural approach, in which the dura is opened along the sphenoidal ridge (*Fig.* 581), was always used in preference to the intradural route, which is probably easier. The covering dura protects the inferior surface of the frontal lobe and also prevents excessive retraction, so that there is less danger of snapping off veins entering the sagittal sinus or of damaging the brain, thereby reducing the risk of post-operative œdema and of late epilepsy.

Some surgeons prefer a more lateral (intradural) approach along the wing of the sphenoid after reflecting an anteriorly placed lateral osteoplastic flap; this lateral frontal approach had been in general use before the introduction of the anterior extradural (transfrontal) operation. It is believed, however, that the latter approach gives a much better view of the chiasma and the contralateral optic nerve, and more direct access over the tuberculum sellæ into the sella without any danger of injuring the right optic nerve and the carotid or cerebral vessels.

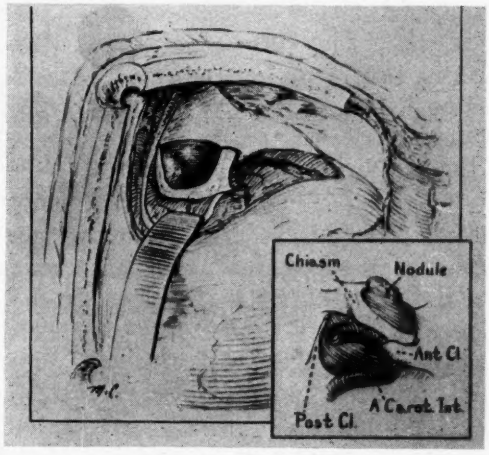


FIG. 582.—Exposure of the optic nerves and chiasma and the bulging pituitary adenoma with a secondary nodule alongside the left optic nerve. The olfactory nerve is seen, and inset gives an imaginary lateral view from the right side.

In exposing the tumour, it is not necessary in the beginning to retract the brain sufficiently to expose the entire chiasma, but the whole of this structure must be in view after the tumour has been excavated. It is important, however, to identify the contralateral optic nerve and keep it in view during the manipulations on the tumour. The tumour should be aspirated before it is incised in order to exclude the possibility of aneurysm, which can closely resemble an adenoma, and to ascertain if the tumour is cystic.

The presenting capsule of the adenoma, which is covered by the stretched diaphragma sellæ, is incised electrically after coagulating the small vessels on its surface, care being taken not to transmit any heat to the optic nerves. If the tumour is soft, its contents begin to extrude at once and can be removed with spoon or suction. The firm, fibrous tumours are more difficult to deal with and have to be excavated piecemeal with pituitary rongeurs. It is possible to make a thorough excavation of the intrasellar portion of the tumour under direct vision by the transfrontal approach, except when the tumour is very tough and rubbery, which renders its even fragmentary removal difficult. As regards the capsule itself, only the readily accessible portion of its upper part is removed. The optic nerves and chiasma

must be completely liberated by withdrawing the capsule inwards from below each nerve and forwards from beneath the chiasma; in doing this, a nubbin of tumour, which had penetrated the diaphragma through the normal opening for the pituitary stalk, may be pulled forwards from under the chiasma (*Fig.* 582) where it lay concealed from view. The capsule must be drawn forwards from the base of the brain until the whole vault of the tumour is removed so as to exclude the possibility of leaving behind a portion of the tumour (*Fig.* 583)*. Finally, the edges of the capsule are coagulated and shrivelled up electrically, and are infolded into the tumour cavity, after which the nerves and chiasma are quite free. Drainage was very seldom employed. When there is troublesome oozing from the cavity it may arrested by carefully packing with pieces of wool moistened with Zenker's fluid.

This procedure has hitherto been conveniently described as a transfrontal operation. This designation, however, is now sometimes applied to the more recent transventricular operations in which a median suprasellar tumour which has occluded the third ventricle, e.g., colloid cyst, craniopharyngioma, or more rarely a suprasellar extension of a pituitary

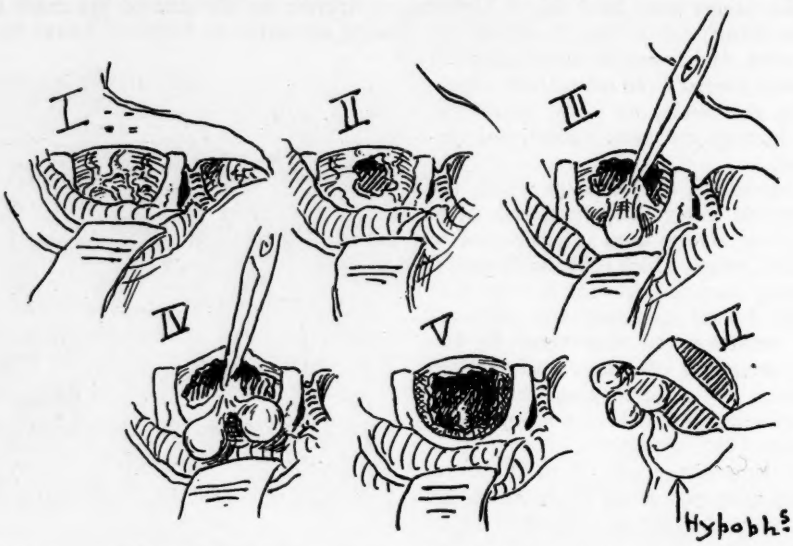


FIG. 583.—Operative sketches from case history of P.B.B.H. Surg. No. 35613. For explanation of this figure, *see* footnote.

adenoma (it was used in one case in this series), is approached through the frontal horn of the lateral ventricle. The classical transfrontal operation in which the frontal lobe is elevated would perhaps be more accurately referred to as a subfrontal operation.

3. The Lateral Osteoplastic Procedure.—This operation was used with success on several occasions during the last few years in cases with a large extension of the adenoma into the temporal lobe. The decision to use this approach usually depended upon ventriculographic demonstration of the extension and its exact position; in some cases there had already been an unsatisfactory transfrontal exploration. There is no doubt that, combined with ventriculography, it will be used more often in future, especially when the extension is on the right side and there is no possibility of aphasia following an incision through the temporal cortex.

4. Subtemporal Decompression.—This was a relatively common operation in the early days of pituitary surgery, but there is very rarely an indication for it at the present

* It has been Dr. Cushing's invariable custom to dictate a full description of every operation immediately on its conclusion, and also to make a series of rough sketches while the details of the procedure are still fresh in mind. Thus *Fig.* 583 shows the successive stages of the transfrontal excavation of a suprasellar chromophobe adenoma (P.B.B.H. Surg. No. 35613): (I) The adenoma as first seen bulging between the optic nerves below a vascular diaphragma; (II) The primary opening in the capsule through which the tumour is excavated (usually by scoop or suction); (III) Mobilization of the empty capsule reveals an unsuspected retrochiasmal nodule; (IV) Two additional retrochiasmal nodules withdrawn prior to removal; (V) The remaining capsule has fallen away from the optic nerves—in the depth of the pocket the pituitary stalk is now seen; (VI) To show presumed relationship of the suprasellar adenoma to optic nerves, chiasma, and slightly flattened pituitary body.

time. It was occasionally used as a preliminary to other operations in the rare cases with papillœdema, and more often as a palliative measure for the relief of general pressure symptoms, especially severe bursting headaches, after other operations had been unsuccessful in the last stages of an advanced intracranial extension; it usually gave temporary relief in such cases.

5. Ventriculography.—This preliminary investigation was used to demonstrate an intracranial extension in certain cases with homonymous hemianopia or unilateral blindness, before reflecting a large transfrontal or a lateral osteoplastic flap.

II. THE CHROMOPHOBE ADENOMATA

The surgical results in the 260 cases of chromophobe adenoma will be described under three main headings: (*A*) Operative mortality. (*B*) The early results of operation, especially as regards the improvement in vision and the patient's ability to return to work. The various types of visual field defects that occur with pituitary tumours and their importance in relation to surgical approach will be discussed. (*C*) The late or follow-up results, with observations on the beneficial effect of supplementary post-operative X-ray treatment.

Separate sections are devoted to the treatment of recurrences, to the results in cases with cystic adenomata, to the cases with nasopharyngeal extensions, and to post-operative blood-clots. Finally, there is a short note on intracranial extensions.

A. THE SURGICAL MORTALITY STATISTICS

The chief risk of the transsphenoidal operation is meningitis, which is apt to occur if a cerebrospinal fluid leakage develops and forms a free communication between the subarachnoid space and the nasopharynx. This danger of infection, however, has probably been exaggerated in the past. With the transfrontal operation, on the other hand, complications of another sort have to be considered, most of which are traumatic, such as the possibility of contusion to the frontal lobe causing post-operative œdema and perhaps late epilepsy; of injury to the internal carotid, anterior cerebral, or ophthalmic arteries; of further damage to the optic nerves by direct trauma, which would defeat the main purpose of the operation; and of disturbing the hypothalamic centres which are so closely related to the upper part of the tumour. The great tendency in pituitary cases for post-operative bleeding to occur, either under the bone-flap or around the chiasma, is perhaps the most dangerous complication of the transfrontal operation, because the clot is often difficult to recognize and is apt to remain unsuspected.

The comparative mortality statistics of the transsphenoidal and intracranial (usually transfrontal) operations are shown in *Table II*. The figures for the total number of operations do not include 30 transfrontal re-elevations for actual or suspected blood-clot formation, 4 transsphenoidal re-explorations for suspected refilling of a cyst, and 10 preliminary ventriculography operations. The usual custom of counting all patients who died in hospital from any cause whatsoever as post-operative fatalities has been adhered to.

Of the 260 patients with chromophobe adenomata, 167 had transsphenoidal operations, with 8 fatalities, and 93 had intracranial operations, with 5 fatalities. Forty of these patients subsequently had one or more secondary operations in the clinic for recurrence of symptoms, usually a few years after the primary operation. Of these recurrent cases, 4 had transsphenoidal operations for a second time, with 1 death from meningitis; 29 patients had 33 transfrontal operations, with 1 fatality

due to the formation of a blood-clot; in 3 instances intracranial extensions were approached through lateral osteoplastic flaps after previously unsatisfactory transfrontal explorations; and in the remaining 4 cases, early in the series, subtemporal decompressions were made for the relief of headaches due to advanced intracranial extensions.

Table II.—CHROMOPHOBE ADENOMATA: NUMBER OF PATIENTS, OPERATIONS, POST-OPERATIVE FATALITIES, AND OPERATIVE MORTALITY RATE

OPERATION	NUMBER OF PATIENTS	PRIMARY OPERATIONS		SECONDARY OPERATIONS FOR RECURRENCES		OPERATIVE MORTALITY RATE
		Number of Operations	Post-operative Deaths	Number of Operations	Post-operative Deaths	
Transsphenoidal ..	167	167	8	4*	1	5·3 per cent
Transfrontal ..	91	91	4	33†	1	
Lateral flap ..	2	2	1	3‡	–	4·5 per cent
Subtemporal decompression ..	—	—	—	4	–	
Total	260	260	13	44	2	4·9 per cent

* The 4 secondary transsphenoidal operations followed primary transsphenoidal operations.

† 22 of the secondary transfrontal operations followed primary transsphenoidal operations; 11 followed one or more previous transfrontal operations.

‡ The 3 secondary lateral-flap operations followed primary transfrontal operations.

The combined figures for the total number of operations, primary and secondary, show an operative mortality rate of 5·3 per cent for the transsphenoidal route and 4·5 per cent for the intracranial procedures. There was therefore no essential difference between the transsphenoidal and the transfrontal operations as regards the immediate risk of operation. Altogether there were 15 post-operative fatalities after 304 pituitary operations, i.e., 4·9 per cent. The progressive decrease in the mortality rate is shown by the figures for the second ten-year period, during which there were 205 operations (including all routes) with only 5 post-operative deaths, i.e., 2·4 per cent.

Of the 9 fatalities following transsphenoidal operations, 4 were due to meningitis, 3 to the effects of a large intracranial extension of the adenoma, and 2 to hypothalamic disturbance with hyperthermia. Each of these three groups had quite a distinctive post-operative clinical course, which may be indicated briefly. The patients with hyperthermia never fully regained consciousness after operation; they became increasingly restless and irrational, the temperature rose steadily to about 107° in spite of antipyretic measures, the pulse and respirations became very rapid, and death occurred from thirty-six to forty-eight hours after operation. The cause of these hypothalamic crises, which are fortunately rare, is obscure: they may be due to direct trauma or to a localized vascular disturbance which produces œdema or thrombosis. They can also occur after what appears to be a very satisfactory operation on a comparatively small tumour, and post-mortem examination fails to reveal any damage to the base of the brain. In fulminating cases death may occur as rapidly as six hours after operation. A post-operative temperature of 103°–104° as part of a generalized hypothalamic disturbance is a

well-recognized complication of pituitary operations, but it usually settles down in a few days.

In the meningitis group, on the other hand, there was usually an abrupt onset with rigors about the fourth or fifth day after a hitherto satisfactory post-operative recovery; there were the usual features of septic meningitis which progressed rapidly and death followed within another four or five days. In one case the onset was delayed until the twelfth day, and death occurred after the usual course four days later.

The 3 patients with large intracranial extensions (verified at autopsy in one, and reasonably certain from the clinical features in the other two) made a very good immediate recovery, and then died suddenly and unexpectedly at variable times after operation; the first case after twelve hours, the second on the sixth day after sudden dyspnœa and cyanosis (possibly due to pulmonary embolism), and the third case on the fourteenth day after coma of brief duration. In the last case it was shown at autopsy that death had been due to recent hæmorrhage into a large semicystic tumour, and it is reasonable to assume that other cases of sudden death may have been due to the same cause.

The 6 fatalities following intracranial operations were due to the formation of post-operative blood-clots in 3 instances, to cerebral œdema associated with large intracranial extensions in 2, and to hæmorrhage into a cystic intracranial extension in the remaining 1 case.

Unusual risks, from post-operative œdema, are run in the attempt to expose the chiasmal region in the presence of a large intracranial extension. The 2 patients who died from this complication showed increasing restlessness and hyperthermia, and died after forty-eight and seventy-two hours respectively; in both cases the wound had been re-opened twenty-four hours before death to exclude possible clot formation, but nothing was found apart from a tight œdematous brain. In 3 instances death was due to the formation of post-operative clots, which were not recognized sufficiently early for their removal to save the patients; this complication will be referred to in a later section. In the remaining 1 case death occurred from hæmorrhage into a large median cystic extension on the ninth day day after a brief period of increasing drowsiness and hyperthermia.

Summary.—The 6 fatalities after 129 *transfrontal operations* were, therefore, mostly due to the formation of a blood-clot or to cerebral œdema, and occurred usually within two or three days. The commonest cause of death after *transsphenoidal procedures*, on the other hand, was meningitis, which accounted for 4 deaths in 9 fatal cases after 171 operations.

Late Meningitis.—The figures just given show that early meningitis follows transsphenoidal operations less often than is generally supposed, for it caused only 4 deaths after 171 operations (i.e., 2·3 per cent) within the usual two to three weeks before the patients' discharge from hospital. The prevalent belief that the risk of meningitis is the bugbear of the transsphenoidal approach is based largely upon the high mortality in small groups of cases reported in the early days of pituitary surgery. This complication, however, has been minimized by the later method of obviating removal of the turbinates and extensive laceration of the mucous membrane, so as to avoid entering the cavity of the nose. It is assumed, of course, that all the air sinuses are examined and a throat swab is taken before the operation. Another type of case, now well recognized, that contributed to some

of the early deaths, was that in which the third ventricle, dilated by obstructive hydrocephalus and associated with a distended sella and clinical manifestations of hypopituitarism, had been inadvertently drained into the nose.

It is important to point out that the danger of meningitis after these operations is sometimes greatly delayed, and that a patient may succumb, often quite suddenly, to a latent infection weeks, months, or even years later. The intrasellar tumour which remains after a partial removal may become infected and form an abscess which remains latent for a long time before it finally bursts. In discussing mortality rate, therefore, it is only fair to add that 6 patients, all of whom were very well when discharged from hospital, died unexpectedly some time after returning home. In 4 of them death occurred within ten weeks after discharge, but in the remaining 2 it was delayed for seven months and four and a half years respectively (cf. p. 875). Post-mortem examination was made in 4 of these cases, and it was found that a previously latent intrasellar abscess had burst upwards into the basal subarachnoid spaces. It may be noted that 3 of the patients had had radium implanted into the sella either during or after operation.

There does not appear to be any tendency for the development of osteomyelitis in the surrounding bone after transsphenoidal operations.

B. THE EARLY RESULTS OF OPERATION

In assessing the results of operation on the 247 patients who recovered, chief attention has naturally been given to the effect on vision, impairment of which is the outstanding clinical manifestation of chromophobe adenomata, and is, in the great majority of cases, the only serious symptom; headache is not a prominent feature of these tumours, and the effects of pituitary insufficiency are not an indication for surgical treatment. In advanced cases, however, the defective eyesight may be overshadowed by cerebral symptoms due to a large intracranial extension of the adenoma; the persistence of any disability from this cause is, in such cases, of much greater importance in assessing the final result than is any improvement in vision which sometimes follows excavation of part of the tumour from the region of the optic chiasma.

It is easy enough to show accurately the effect of operation in preserving vision in individual cases by comparing the visual charts before and after operation, but it is a difficult matter to know how to present a concise and unprejudiced evaluation of the results in a large series of cases. Some writers have graded results according to the amount of visual recovery, or to the final state of the visual fields or of the visual acuity, but such methods make the results of less value to others owing to the difficulty of interpreting the standards chosen by different authors. It is partly to avoid this difficulty, but chiefly to show the results from the patients' standpoint, that the method adopted in this paper has been based largely on economic considerations. The patients' ability to return to his occupation and lead a normal life is clearly the best indication of the benefit derived from operation.

It has been found convenient to group the early results into six grades, which are shown in *Table III*. In doing this, the cases were divided first of all into three main groups according to whether there was, within a reasonable period following operation, (1) an improvement in vision, (2) no change in vision, or (3) a further deterioration in vision or the presence of other disabling (intracranial) symptoms.

A second division was then made on an economic basis, in which the resumption of occupation was taken chiefly into consideration. The results in the first group have been designated 'very good', 'good', or 'moderate'; in the second group as 'satisfactory' or 'poor'; and in the third group as 'progressive deterioration'. In making these estimates attention has been given to (*a*) whether or not the failure of vision before operation was of such severity that the patient had been incapacitated from his normal occupation (or the housewife unable to read ordinary small print); and (*b*) whether the post-operative vision (improved or unchanged) allowed the patient to resume his normal occupation, or was sufficient only for intermittent work or the adoption of a new occupation for which good vision was less important, or whether it was too poor to enable the patient to be self-supporting.

Table III.—CHROMOPHOBE ADENOMATA: EARLY RESULTS OF THE TRANSSPHENOIDAL AND TRANSFRONTAL OPERATIONS BASED ON THE IMPROVEMENT IN VISION AND ECONOMIC CONSIDERATIONS

CLASSIFICATION OF RESULT OF OPERATION			TRANS-SPHENOIDAL OPERATION	TRANS-FRONTAL OPERATION	TOTAL CASES
1. Vision improved	Very good	Incapacitated by loss of vision; marked improvement after operation; able to resume normal occupation	73	35	108
	Good	Vision impaired, but patient still at work; vision improved after operation; continued with normal occupation	22	13	35
	Moderate	Incapacitated by loss of vision; slight operative improvement, sufficient only for intermittent work or new occupation	19	14	33
2. Vision unchanged	Satisfactory	Vision impaired, but patient still at work; no change after operation; continued with normal occupation	18	8	26
	Poor	Incapacitated by loss of vision; no change after operation; no useful vision remained for work or reading	21	10	31
3. Progressive deterioration		Failing vision or other disabling symptoms continued to progress or new symptoms appeared within six months after operation	6	8	14
		Total	159	88	247

Thus, the successful operations, after which patients returned to an active life and normal occupation, include the 'very good', 'good', and 'satisfactory' groups; although there was no improvement in eyesight in this last group, its failure had been arrested before there was any serious impairment. Operation

was only partially successful in the 'moderate' group, for although the vision, which was usually very poor, showed some improvement, it was insufficient to allow the patients to resume their former occupations; many of them, however, were able to take up different work and enjoy life. In the 'poor' group, vision had already become so seriously damaged that the operation can scarcely be looked upon as having been worth while, as the patients were unable to resume their livelihood, even though some of them remained in good general health for many years without any further deterioration in vision. In the so-called 'progressive deterioration' group the visual failure, even when temporarily arrested or improved, or the disabling effects of an intracranial extension, either continued or appeared within six months after operation, which in some cases seemed at the time to have been beneficial; in some instances the lesion was so far advanced that not only did the operation give no relief, but, as events proved, it was evidently ill advised.

Only 4 patients showed a further loss of vision before their discharge from hospital, and this must, of course, be attributed to the surgical interference. All had transfrontal operations, 3 of which were secondary interventions for recurrence of symptoms (the results of secondary operations will be considered in a later section). In one of them the decline of vision was noticed immediately after operation and it was thought at the time that the optic nerve had been damaged during the manipulations on the tumour. In the others the further loss of vision did not appear until two or three weeks later, after there had been a transient post-operative improvement, and was almost certainly due to the formation of an unrecognized suprasellar blood-clot; this complication will also be referred to later. Two of them became virtually blind, which was singularly unfortunate because they have remained well and free from any sign of recurrence for nine years (*Case* 26) and thirteen and a half years (P.B.B.H. Surg. No. 20379).

These statistics of early results cover a six-months' post-operative period in order to be certain that vision which did not show any change during the patient's stay in hospital was not merely an undetected slow regression; and also to allow reasonable time for maximum recovery to take place, which, especially after the transsphenoidal operation, may require this length of time.

It is seen from *Table III* that of the 247 patients who were discharged from hospital, 169 returned to full work ('very good', 'good', and 'satisfactory' groups), i.e., 68 per cent, and that there was no essential difference between the two operations in this respect. This represents 65 per cent of the total number of 260 patients before operation. The visual recovery, however, was usually more complete after transfrontal operations; this fact was brought out in a previous analysis,[10] based solely on the degree of improvement in the visual acuity and fields, in which it was stated that " only 9 per cent of the transsphenoidal operations, in contrast to 21 per cent of the transfrontal operations, were followed by restoration of the visual acuity and fields essentially to normal ".

Taking the 'satisfactory', 'poor', and 'progressive deterioration' groups together, there were 71 patients, i.e., 29 per cent, who did not show any improvement after operation. Again, there was no difference between the transfrontal operations, in which the optic nerves are directly exposed to the possibility of operative trauma, and the transsphenoidal operations in which the excavation is made at the base of the tumour. Many of these were advanced cases in which

the optic nerves had been severely and permanently damaged by long-standing compression and were therefore incapable of showing any restoration of function.

I have recently had an opportunity of observing at the post-mortem examination on two cases with advanced loss of vision, a mechanism by which the visual pathways may be permanently damaged. The upper end of an ordinary intrasellar chromophobe adenoma, without any gross intracranial extension, had compressed the optic nerve in a patient with unilateral blindness, and the optic tract in a patient with homonymous hemianopia, against the anterior cerebral artery. In both instances the artery had produced such a deep constriction that the nervous tissue was completely divided, although the two ends were still held together by a thin layer of membranes, so that any recovery of vision would have been impossible.

That such a vascular constriction may occur has, of course, long been known, and it is highly probable that the absence of improvement after operation is not infrequently due to the fact that the nerve has already been severely constricted by the anterior cerebral artery. In the less severe cases, a shallow arterial groove is frequently seen on the upper surface of the optic nerve or tract during transfrontal explorations, as has often been depicted by Cushing in his papers concerning operations in this region. The possibility that such localized and irreparable damage may supervene at any time, without any means of knowing when, even although the tumour may be quite small, emphasizes the necessity of completely liberating the optic structures without delay in all cases.

The absence of improvement in other instances, however, particularly after a relatively brief clinical history, is probably due to the presence of an unsuspected extrasellar mass or secondary nodule of the adenoma in some unusual position which might possibly be indicated by a particular type of defect in the visual fields. It seemed desirable, therefore, to regroup the entire series on an anatomical basis, on the assumption that each of the several distinctive types of visual field defect represents a particular relationship between the position of the optic chiasma and the direction of tumour growth. Should this prove to be so, then it might be possible to indicate the type of case that is likely to have a bad prognosis, and it might also be of value in selecting the operation most suitable for each case. The groups that have been adopted for this purpose are, therefore, based entirely on the type of defect in the visual fields and are shown in *Table IV* for the transsphenoidal operations and in *Table V* for the transfrontal operations. They are as follows :—

1. **Bitemporal Hemianopia.**—There were 165 patients with the typical upper quadrantic or complete bitemporal hemianopia, including those in whom the visual defect had progressed to blindness in one eye at the time of admission to hospital, with a clear history of bitemporal constriction of the visual fields. Patients with lower quadrant defects are not included. This is naturally the largest group; it contains about 65 per cent of the cases. The chiasma was usually displaced upwards and backwards by the dome of the adenoma which bulged through a wide prechiasmal space.

2. **Homonymous Hemianopia.**—This was present in 20 cases, which, with the additional 3 post-operative fatalities, represent about 10 per cent of chromophobe adenomata. It indicates growth of the adenoma off to the side in such a direction that it either impinges on the optic tract behind the chiasma or involves the optic radiation within the temporal lobe.

Table IV.—CHROMOPHOBE ADENOMATA: EARLY RESULTS OF THE TRANSSPHENOIDAL OPERATION IN ACCORDANCE WITH THE TYPE OF VISUAL FIELD DEFECT

TYPE OF DEFECT IN VISUAL FIELDS	RESULT OF TRANSSPHENOIDAL OPERATION (classified as in *Table III*)						TOTAL CASES
	Very Good	Good	Moderate	Satisfactory	Poor	Progressive Deterioration	
1. Bitemporal	58	18	10	13	12	—	111
2. Homonymous	3	2	—	2	—	1	8
3. One eye blind	2	2	2	—	3	5	14
4. Central scotoma or inferior quadrant	10	—	5	—	1	—	16
5. Only one eye affected	—	—	—	3	1	—	4
6. Blind	—	—	2	—	3	—	5
7. Normal vision	—	—	—	—	1	—	1
Total	73	22	19	18	21	6	159

Table V.—CHROMOPHOBE ADENOMATA: EARLY RESULTS OF THE TRANSFRONTAL OPERATION IN ACCORDANCE WITH THE TYPE OF VISUAL FIELD DEFECT

TYPE OF DEFECT IN VISUAL FIELDS	RESULT OF TRANSFRONTAL OPERATION (classified as in *Table III*)						TOTAL CASES
	Very Good	Good	Moderate	Satisfactory	Poor	Progressive Deterioration	
1. Bitemporal	27	11	5	6	4	1	54
2. Homonymous	2	—	6	—	2	2	12
3. One eye blind	—	—	2	2	4	3	11
4. Central scotoma or inferior quadrant	2	—	—	—	—	—	2
5. Only one eye affected	3	1	—	—	—	—	4
6. Blind	—	—	1	—	—	1	2
7. Normal vision	1	1	—	—	—	1	3
Total	35	13	14	8	10	8	88

3. One Eye Blind and the Other Eye Affected.—These patients could not be included with certainty in either of the preceding groups because of the absence of a clear history of the type of hemianopia before the onset of unilateral blindness. This was due in some instances to the accidental discovery that one eye was already blind when the involvement of the seeing eye was first noticed, and in others to the fact that although the patient was aware of the defective eyesight in both eyes, its mode of onset had not been observed accurately before unilateral blindness supervened. In all cases the seeing eye showed a temporal defect. This group, which is, therefore, a collection of advanced cases from Groups 1, 2, and 4, proved to be the most disappointing surgically; the operative mortality rate was high (14 per cent) and the early and late results were poor. Only 6 of the 25 patients returned to full work after operation.

4. Central Scotoma or Inferior Quadrantal Defects.—The patients in this group had either a marked central (not paracentral) scotoma in one or both eyes, without any hemianopic defect in the peripheral field; or a predominantly lower quadrantal defect, usually in the temporal field. It is believed that these less

common field defects when bilateral are apt to occur when the dome of the tumour is projecting upwards behind the chiasma and pushing it forwards.

5. Only One Eye Affected.—The patients in this group, only 8 in number, were seen either at a very early stage of visual impairment or had a postfixed chiasma, so that only one optic nerve had been involved by an asymmetrical growth.

6. Bilateral Blindness.—There were 7 instances in the series.

7. Normal Vision.—Four of the patients with expanded sellae had normal acuity without field defects.

Attention may be drawn to the following deductions from *Tables IV* and *V* :—

a. Both the transsphenoidal and the transfrontal operations have been generally successful in cases with the typical bitemporal type of defect, and on an economic basis there is no striking difference in the results of the two operations.

b. The results have been variable when there was an homonymous hemianopia, but are on the whole better after the transsphenoidal operation.

c. The results have been disappointing when there was early blindness in one eye.

d. Operation has been very successful when the predominant field defect is a central scotoma or an inferior quadrantal defect.

e. The transfrontal operation has given a better result when only one eye is affected.

f. The majority of the patients in the ' progressive deterioration ' group, in which operation had no effect in arresting the progress of the symptoms, had either an homonymous hemianopia or early blindness in one eye.

These observations will now be amplified by the citation of case reports.

Case Reports

1. Bitemporal Hemianopia.—The first two patients chosen to illustrate the results of operation in cases with bitemporal hemianopia happen to have been operated on within a few weeks of each other in 1917, one by the transsphenoidal route and the other by the transfrontal route. They are still leading normal, active lives.

Case 1.—C. L. H., aged 41 years, a physician (P.B.B.H. Surg. No. 6160), was admitted on *Jan.* 27, 1917. He had observed a progressive failure of vision in the right eye, beginning in the upper temporal quadrant, during the previous three years, and a recent involvement of the left eye during the last six months before admission. He had never had any headache, his general health was good, and he was engaged in active medical practice as usual.

Examination showed bitemporal hemianopia (*Fig.* 584) and primary optic atrophy which was more advanced in the right eye. V.O.S. 20/30; V.O.D. 1/200. The sella turcica was only slightly enlarged (20 × 10 mm.).

A transsphenoidal operation was performed on *Feb.* 2, 1917. The thin, intact bone of the sellar floor was punched away and a few fragments of solid tumour were removed, but, to quote from Dr. Cushing's operative note, " the operation was left largely as a decompression ". This was followed by prompt and almost full recovery of vision in the left eye, but there was only slight improvement in the right eye (*Fig.* 585).

He continued his work as a medical practitioner, and has since lived an active life. He wrote on *Oct.* 27, 1936, to say he was still well, almost twenty years after operation. He never had X-ray treatment.

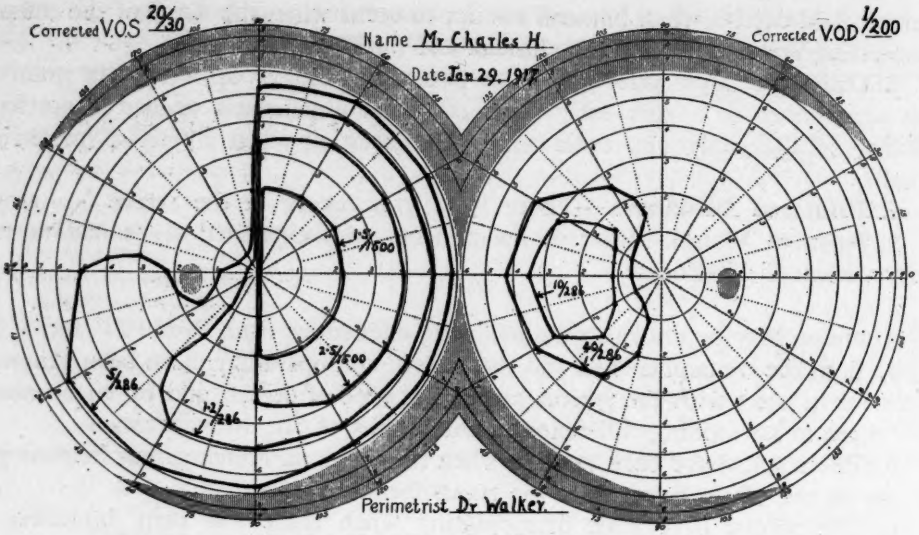


FIG. 584.—*Case* 1. Visual fields on admission.

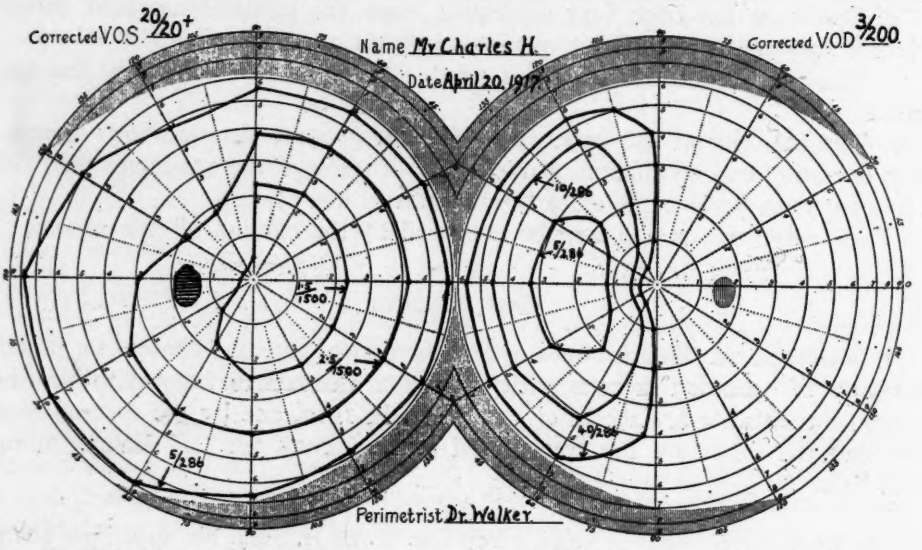


FIG. 585.—*Case* 1. Visual fields after a sellar decompression by the transsphenoidal route.

COMMENT.—A survival period of nearly twenty years without recurrence of symptoms after a transsphenoidal operation deserves special attention, as the excellent end-results of some of these early transsphenoidal cases are not generally known. It may be noted, especially in regard to the possible value of post-operative X-ray treatment as a means of checking the further growth of the remaining tumour (a question to which I shall return), that very little tissue was removed. The tumour, without any further treatment, apparently became quiescent after the decompression, which was sufficient to allow recovery of normal acuity in the left eye, the failure of which had been the cause of the patient's immediate trouble.

In the next case the tumour had not expanded the sella, so that there was some uncertainty before operation about the cause of the hemianopia, and for this reason the chiasma was explored by the transfrontal route.

Case 2.—A. Z. K., aged 23 years, a draughtsman (P.B.B.H. Surg. No. 6483), was admitted on *March* 24, 1917, with the complaint of blurred vision, which he had first noticed only two months previously. Six weeks before admission it was found that vision in the right eye was reduced to light perception in the nasal field. There had been occasional slight frontal headaches for about twelve months, and during the last three months he had gained 10 lb. in weight.

Examination showed bitemporal hemianopia (*Fig.* 586) and slight pallor of the optic discs. V.O.S. 20/50; V.O.D. light perception. The sella was not enlarged (15 × 7 mm.).

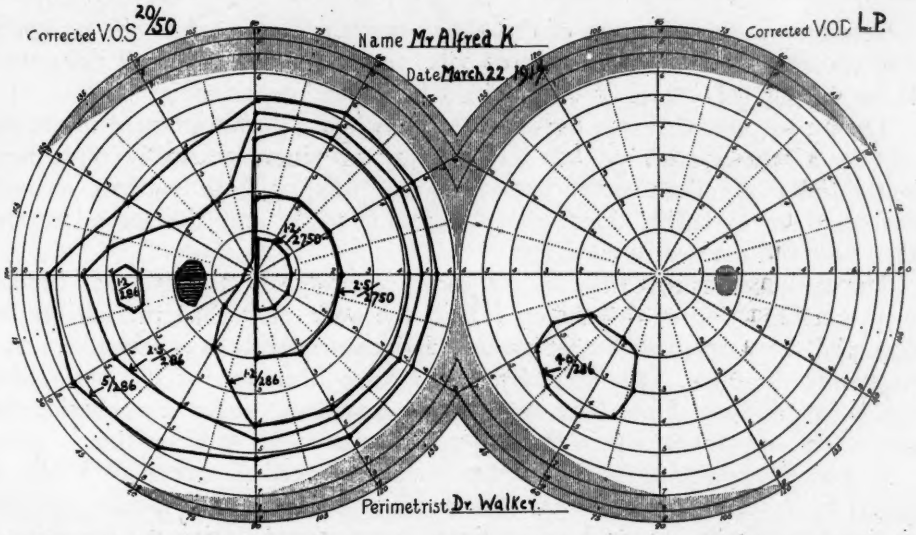


FIG. 586.—*Case* 2. Visual fields before the transfrontal excavation of a suprasellar adenoma which was followed by complete bilateral restoration of central and peripheral vision.

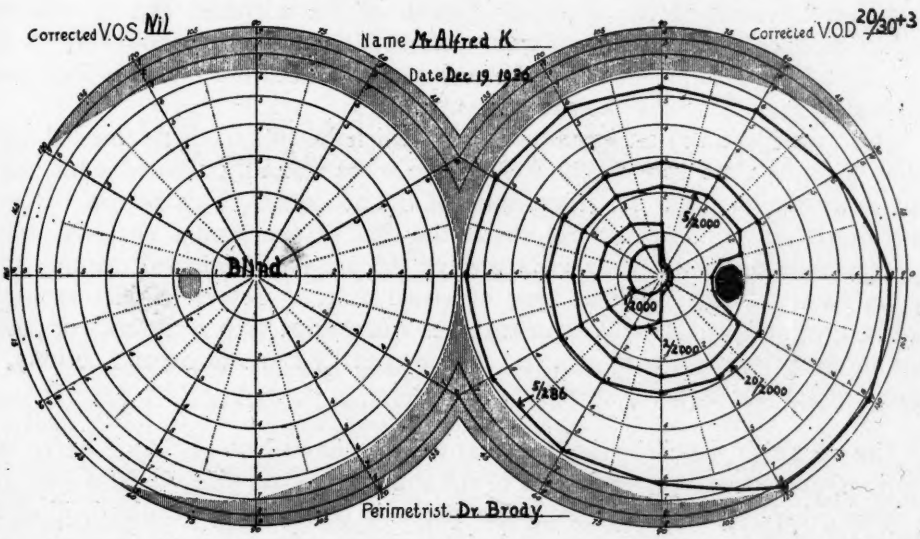


FIG. 587.—*Case* 2. Recently taken fields showing the well-preserved vision in the originally more seriously affected right eye, although the left eye became blind from a recurrence sixteen years ago.

On *March* 30, 1917, a right transfrontal exploration was made, and a solid tumour, which was protruding through the prechiasmal space, was excavated. This was followed by immediate recovery of vision in both eyes, and when he reported three months later the V.O.S. was 20/15 and the V.O.D. 20/20, with fully expanded fields. No X-ray treatment was given.

Vision began to fail again about *March*, 1918, this time in the left eye, which became totally blind by *November*, 1920. In *January*, 1921, he had a transsphenoidal operation with local applications of radium in a European clinic. This did not produce any improvement, but the right eye has continued to remain unaffected and since then he has been working full time teaching higher mathematics and foreign languages.

When he came to New Haven for examination on *Dec.* 19, 1936, he was in excellent general health and had practically normal vision in the right eye (*Fig.* 587). He married in 1929 and now has a boy 6 years of age. During the last two years he has had occasional momentary attacks suggestive of petit mal, but they have caused him no great inconvenience.

COMMENT.—This was one of the early experiences that led to the recognition of the occurrence of suprasellar adenomata, situated above a normal unexpanded sella, as one of the causes of unexplained bitemporal hemianopia.

These two cases illustrate the statement which was made in regard to the early results as a whole, namely, that the recovery of vision is usually more nearly complete after the transfrontal operation, for, whereas both patients recovered sufficient vision to enable them to return to full work, only the second regained normal vision in the nearly blind eye.

The striking improvement in the more seriously affected eye was probably due to a combination of two factors; first, the optic nerve had presumably been compressed for a relatively short period, and consequently was less likely to be permanently damaged, and, secondly, the greater liberation of the optic nerves which is possible when the tumour capsule is mobilized under direct vision from above. The operative sketches in *Case* 3 and others will illustrate this.

It was disappointing to learn that such an excellent operative result was followed by a recurrence of visual failure one year later. The radium treatment (it is not known whether any tumour tissue was removed during the operation for the implantation of radium) did not produce any noticeable improvement, but it had apparently arrested the recurrent growth of the adenoma and he still has excellent monocular vision after sixteen years. The late result, however, on the basis adopted for this paper, has to be reckoned as a recurrence at one year, even though it did not have any serious effects.

This case illustrates an important point which has always been insisted upon by Dr. Cushing; he very rarely divided the more seriously affected optic nerve in an endeavour to get a better exposure of the adenoma. This patient has now relied for sixteen years upon what was at the time of operation a virtually useless eye. Recurrences do not necessarily involve the previously affected eye and they may produce a totally different type of visual defect. Several similar examples could be given of patients who returned after a few years with recurrence of failing vision in the previously good eye, and who eventually came to depend entirely, as in this case, on the formerly poor eye.

The operative sketch in the case that follows shows how one optic nerve may be seriously damaged by a projection of the adenoma to one side, under a stretched but intact, diaphragma, while the other nerve is only slightly involved, if at all. It illustrates what may be accomplished by the transfrontal operation, especially when the eyes are so unequally affected.

Case 3.—Doris C., aged 23 years, a typist (P.B.B.H. Surg. No. 35865), was admitted on *Feb.* 19, 1930, with the complaint of poor vision in the right eye. Menstruation had ceased suddenly three years previously and she then began to have slight right frontal headaches. During the last one and a half years she had observed a progressive blurring of

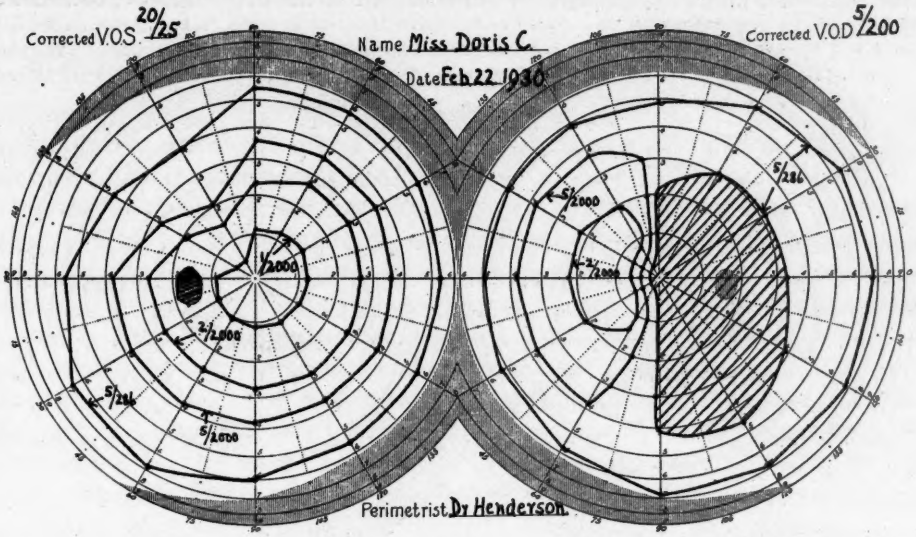


FIG. 588.—*Case* 3. Visual fields on admission, showing a scotomatous type of temporal hemianopia on the right.

vision in the right eye, without any noticeable hemianopia, and she had gained 20 lb. in weight. She had not observed any visual impairment in the left eye.

Examination showed V.O.S. 20/25 with beginning upper temporal defect; V.O.D. 5/200 with almost complete temporal hemianopia (*Fig.* 588). There was moderate pallor of the right optic disc; the left disc was normal. The sella was widely expanded (23 × 18 mm.).

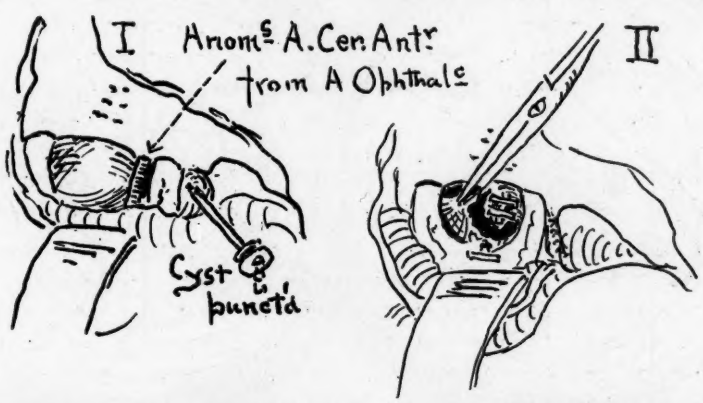


FIG. 589.—*Case* 3. Operator's sketch I shows the adenoma bulging between the optic nerves, aspiration of the cystic extension to the right, and the position of the anomalous (anterior cerebral) artery. Sketch II shows mobilization of the empty capsule after excavating the tumour; also the ends of the divided right anterior cerebral artery with clips applied.

On *March* 6, 1930, a right transfrontal exploration disclosed a large adenoma with an extension to the right underneath the right optic nerve, which was greatly flattened and was displaced directly upwards against the upper margin of the optic foramen (*Fig.* 589). A large anomalous artery lay alongside the medial border of the right optic nerve. The tumour was protruding on the outer side of the optic nerve and still farther to the right there was a

rather small carotid artery. The protrusion on the right of the optic nerve was aspirated to exclude the possibility of aneurysm; it contained a small quantity of cystic fluid. The tumour was incised and excavated in the usual manner.

The left optic nerve had not been seriously affected by pressure, but a small nodule of tumour was found projecting through the posterior part of the diaphragma, underneath the

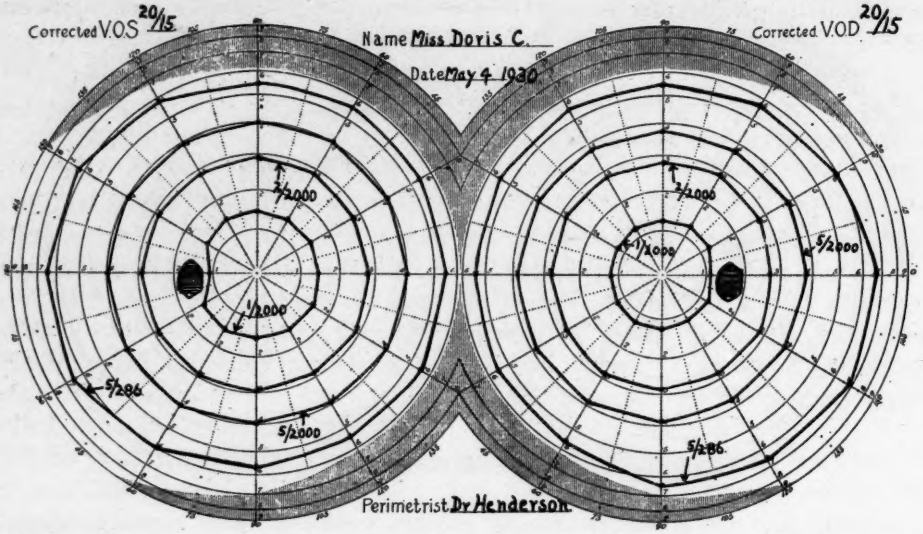


FIG. 590.—*Case* 3. To show the completely normal fields of vision two months after the transfrontal operation.

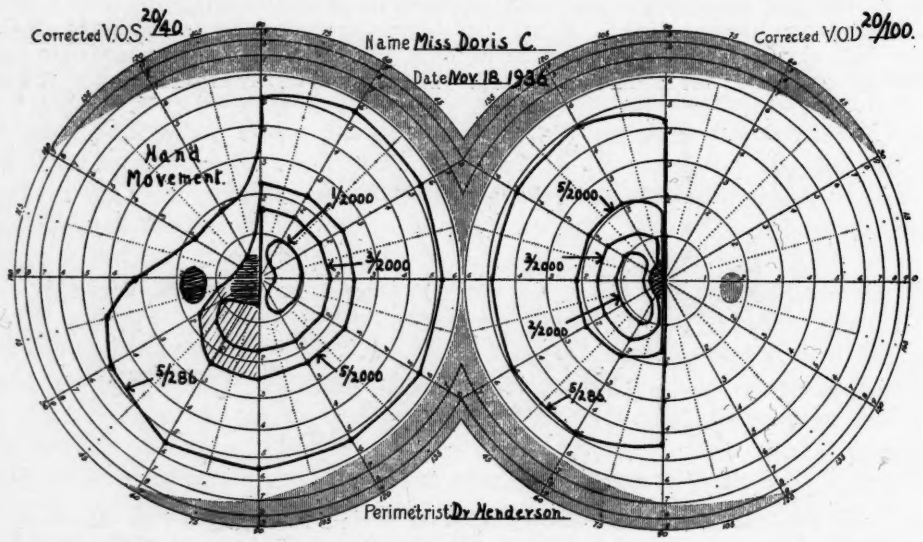


FIG. 591.—*Case* 3. Recent fields to show the recurrence of visual failure which has remained stationary since X-ray treatment three years ago.

chiasma. It was necessary to divide the anomalous artery between silver clips in order to facilitate the withdrawal of the capsule from under the right optic nerve, which then immediately rounded out to its normal shape. The anomalous artery proved to be the anterior cerebral, which was being given off by the ophthalmic artery.

The visual acuity and fields were restored to normal (*Fig.* 590) within a few weeks of operation and she returned to work. There were no noticeable effects from the division of the anterior cerebral artery. She did not have X-ray treatment.

Vision in the right eye began to fail again three and a half years later, and she was compelled to cease work. A series of X-ray treatments (fifteen exposures) were given during the following year, but there was no improvement. When she was examined at New Haven on *Nov.* 18, 1936, there had been no further deterioration in vision (*Fig.* 591) and her health was good.*

COMMENT.—The presence of a lateral protrusion of the tumour under the right optic nerve makes it unlikely that an equally good surgical result would have been obtained by the transsphenoidal route.

The X-ray treatment did not produce any improvement, but it apparently arrested, at least for a time, the growth of the adenoma. The question naturally arises as to whether the symptoms of recurrence would have been longer delayed or prevented by immediate post-operative X-ray therapy, and whether a secondary operation as soon as the recurrence revealed itself, in preference to the X-ray therapy, would have restored vision and enabled the patient to be still at work. These questions cannot be answered for a specific case, but judging from the results of post-operative X-ray therapy and of secondary operations, which will be described later, and from the fact that her vision has been stationary for the last three years, it is highly probable that, had either of these measures been adopted, this patient's vision would have been better than it is at the present time.

Case 4.—Mrs. Gladys H., aged 42 years, a doctor's wife (P.B.B.H. Surg. No. 36508), entered the hospital on *May* 18, 1930. She gave an accurate description of the discovery of a temporal hemianopia in the left eye ten years previously, which had since remained

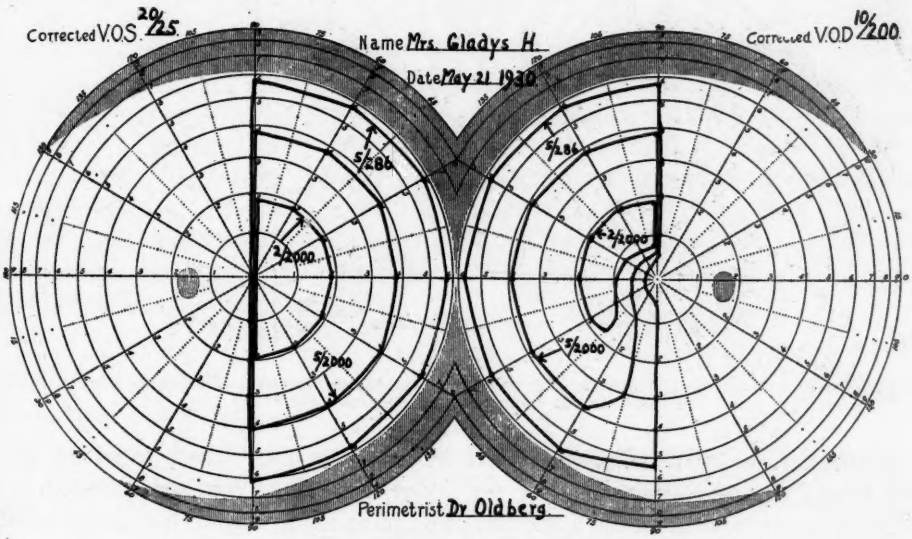


FIG. 592.—*Case* 4. Visual fields on patient's admission.

stationary; also of the appearance of a progressive temporal hemianopia in the right eye during the last twelve months. There had been amenorrhœa for fourteen years.

* Re-examination at New Haven on June 16, 1938, revealed symptomatic evidence of recurrence. She complained of headache and pain in the left eye, and somnolence. V.O.S. 20/65; V.O.D. fingers at 2 feet. Dr. Cushing advised exploration, but this was refused.

Examination disclosed a complete bitemporal hemianopia (*Fig.* 592) with V.O.S. 20/25 and V.O.D. 10/200. There was marked atrophy of the left optic disc, but only slight pallor of the right disc. The sella was widely expanded.

On *May* 28, 1930, a right transfrontal exploration was made, exposing the right optic nerve and the bulging dural diaphragma. The large, soft, intrasellar adenoma was radically excavated by suction. Mobilization of the capsule then revealed a small supradiaphragmatic mass of tumour, which had

FIG. 593.—*Case* 4. Rough sketch to show the supra-diaphragmatic extrusion of the adenoma which conceals the left optic nerve. The core of the soft adenoma has been sucked out through the central opening and the right optic nerve hangs quite free.

extended through an opening in the posterior part of the diaphragma under the chiasma and had covered the left optic nerve (*Fig.* 593). This extrusion was removed by suction, after which the optic nerves and chiasma were quite free.

The operation was followed by striking improvement of vision in the right eye to 20/30 and slight widening of both lower temporal fields (*Fig.* 594).

In *October*, 1936, i.e., six and a half years after operation, she wrote to say that she was well and had good vision in both eyes. She never had X-ray treatment.*

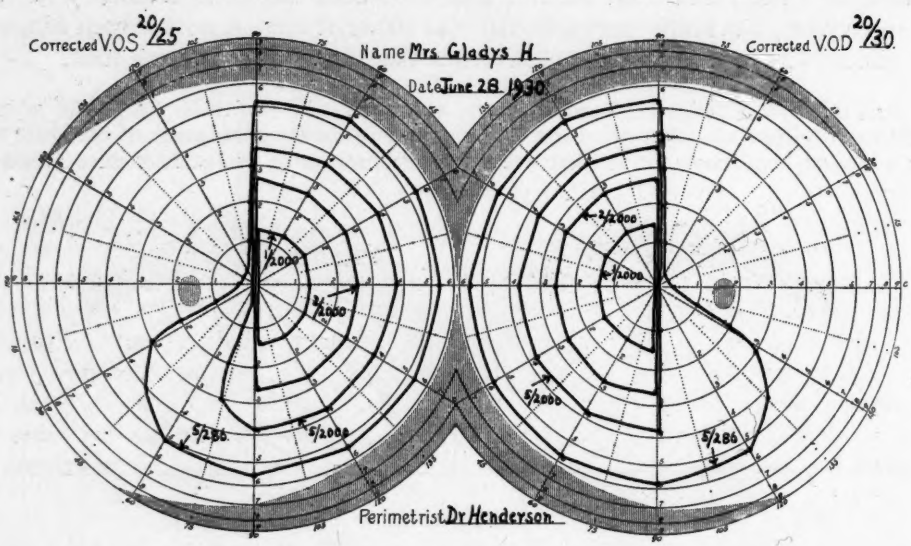


FIG. 594.—*Case* 4. The visual fields four weeks after the transfrontal operation. Note the improved acuity in the more seriously affected right eye.

COMMENT.—The noteworthy points in this case are: first, the long period (nine years) during which the left eye alone was affected; and, secondly, the absence of improvement in the apparently less seriously involved, but longer affected and consequently more atrophic, left optic nerve, as compared with the right.

The exact mechanism by which the average, more or less rounded pituitary tumour, projecting upwards as it usually does through the prechiasmal space, affects the visual fibres so as to produce bitemporal loss of vision, which is rarely

* In a recent letter on Aug. 18, 1938, her doctor said that she was looking well and was working at the post office.

symmetrical, is still uncertain. The old controversy, which was based chiefly upon the study of post-mortem specimens, as to whether the direct pressure of the tumour on the adjacent fibres in the optic nerves or in the chiasma, or the tension and strangulation of the interwoven crossed fibres by one another in the stretched chiasma, is the more important in blocking the visual impulses from the nasal retinæ remains unsettled, nor is it of any great practical importance.

Mention of this would be irrelevant in this paper were it not that the transfrontal operation has afforded an opportunity of observing the actual relationship of the various structures in situ, and has made it apparent that other mechanisms have a share in producing visual-field defects, particularly of the less common types. Localized pressure by a small nodule of tumour, the forward displacement of a prefixed chiasma by a tumour pressing on its posterior margin, and particularly the displacement of the optic structures against the anterior cerebral arteries or the margins of the optic foramina, which act as sharp lines of counterpressure, are just as likely to produce serious and permanent damage to the optic nerves as is the simple stretching of the nerves by a smooth rounded tumour. These points are illustrated by the various operative sketches in this paper.

SUMMARY OF GROUP 1.—These four case-reports, which are representative of the large clinical group with bitemporal hemianopia, indicate some of the factors that modify the results of operation. They show that bitemporal hemianopia is not always due to simple stretching or compression of the chiasma and optic nerves by a bulging, rounded prechiasmal adenoma, and that the transfrontal operation is likely to give better visual recovery, particularly when the eyes are asymmetrically involved. Operation is successful in nearly all cases provided it has not been delayed until the nerves are permanently damaged.

2. Homonymous Hemianopia.—It is perhaps surprising that several patients with homonymous hemianopia, the frequency and significance of which is not generally recognized, should have done well after a decompression of the adenoma from below. Thus 5 of the 8 patients who had a transsphenoidal operation showed considerable improvement (*Table IV*) which, in some of them, has been maintained for many years. The selection of the transfrontal route in some of the more advanced cases with large intracranial extensions possibly accounts for the generally disappointing results after that procedure (*Table V*), for only 2 of the 12 operations can be regarded as successful.

The following case provides an example of a successful transsphenoidal operation, as regards both the early and the late results, in a patient with homonymous hemianopia.

Case 5.—Bert W., aged 50 years, a shoeworker (P.B.B.H. Surg. No. 6232), was admitted on *Feb.* 9, 1917. He complained of failure of vision, which had started in the left eye eighteen months previously and within ten months had progressed to retention of mere light perception. Failing vision in the right eye was first observed twelve months before admission, and for the last six months an inability to see the right half of objects had been noticed. There had been no headache or other symptoms.

Examination showed primary optic atrophy which was more marked in the left eye, and a complete right homonymous hemianopia (*Fig.* 595). V.O.S. hand movements; V.O.D. 20/70. The sella was large (30 × 20 mm.).

On *March* 2, 1917, a transsphenoidal operation was performed; a cystic tumour containing brownish fluid was emptied, and fragments of the wall were removed for histological

verification. This was followed by improvement of vision in the right eye, with some recovery of the temporal field, but the left eye remained unchanged.

He continued in good health and remained at work until his retirement ten years later. He wrote in *October*, 1936, almost twenty years after the operation, to say that he had had no further trouble with his eyesight and considering his age was in fair general health. He never had X-ray treatment.

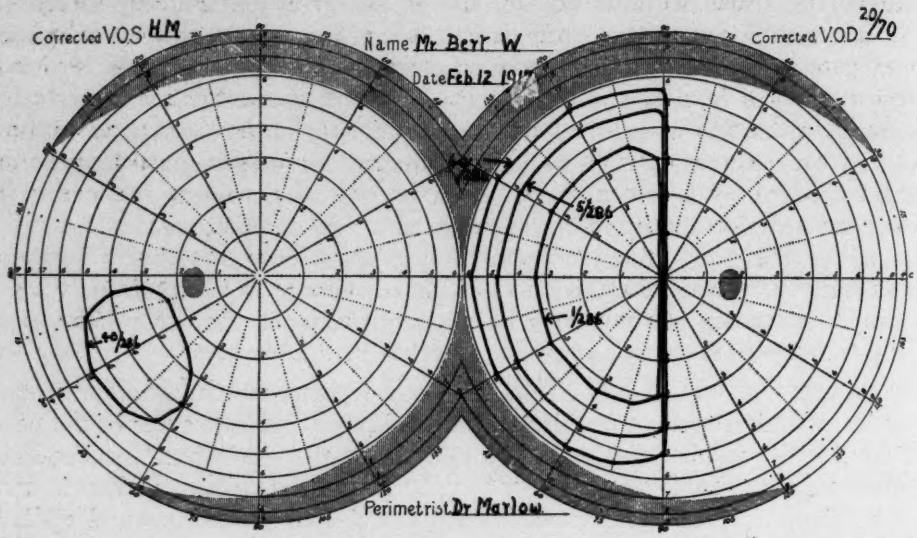


FIG. 595.—*Case* 5. Visual chart on admission showing complete homonymous hemianopia with a marked difference in the visual acuity, which is believed to indicate involvement of both optic tract and optic nerve on the left side. Compare with *Fig.* 596.

A later report states that he died on *July* 13, 1937, after an abdominal exploration which revealed multiple carcinomatous masses and ascites. At post-mortem the small residual pituitary tumour was found and there was no evidence of further growth having occurred since the operation twenty years previously.

COMMENT.—Similarly successful and enduring results were obtained by the transsphenoidal operation in other patients with homonymous hemianopia. In three instances, for example, the early improvement has now been maintained, without any evidence of recurrence, for $7\frac{3}{4}$, $9\frac{1}{2}$, and $10\frac{1}{2}$ years respectively, after the partial removal of a solid tumour from below and without X-ray treatment. In each case there was a marked difference in the visual acuity of the two eyes, as in *Case* 5; in fact, it so hapened that in two of them the acuity of the eye on the same side as the involved optic tract was reduced to 3/200, while that of the opposite eye was 20/30, and in the third case vision was 20/200 in one eye and 20/50 in the other.

It is important to observe that in some cases there was also extensive recovery of vision in the blind homonymous fields. An example of this is that of a man of 24 years of age (P.B.B.H. Surg. No. 20572), who had noticed a complete left homonymous hemianopia for four months. On examination, the visual acuity was found to be 20/20 in the left eye, but only 4/200 in the upper temporal field of the right eye. A transsphenoidal operation, in which a tough solid tumour was partially removed was followed within two weeks by complete restoration of the temporal field in the left eye, and an improvement in the central vision of the right eye to 20/70, together with almost complete restoration of its nasal field.

It is well known that pituitary tumours may produce *homonymous hemianopia*, either (1) by compression of the optic tract near the chiasma or (2) by involvement of the supranuclear optic radiation in the temporal lobe. Knowledge gained from experience with intracranial operations, and particularly the transfrontal exposure of the chiasmal region, has led to a much clearer understanding of the relationship between the visual pathways and intracranial extensions of pituitary tumours.

It appears, from reading through the clinical and operation notes of this group of 23 patients (including the 3 operation fatalities), that there are two well-defined clinical types of homonymous hemianopia, depending on whether the optic tract or the optic radiation has been chiefly involved. It is believed that this distinction is important when deciding on the surgical approach and also as regards the improvement that may be expected to follow operation. The clinical features of these two types will now be indicated briefly.

In the type of which *Case* 5 is an example, the upward extension of the adenoma is probably asymmetrical and, if it projects rather backwards as well as to the side, is liable to impinge on one optic tract just behind the chiasma. This is more likely to happen when the chiasma is prefixed, as it was seen to be during several of the transfrontal operations in cases with homonymous hemianopia, which may, in fact, be regarded as a common type of visual defect in the presence of this anatomical variation of the chiasma. The hemianopia is usually complete, but with a marked difference in the visual acuity of the two eyes; there is a very low central acuity of 20/200 or less in the eyes on the same side as the involved optic tract, due, no doubt, to pressure of the tumour on the optic nerve as well, whereas central vision in the opposite eye is usually well preserved. It was sometimes observed during transfrontal operations in such cases that the optic nerve of the nearly blind eye was displaced upwards by the underlying tumour, while the contralateral nerve was often quite free.

Furthermore, several of these patients had noticed that, in addition to the presence of a homonymous hemianopia, the eye on the same side as the compressed optic tract was much the more seriously affected owing to early involvement of central vision, presumably a result of the upward displacement of the optic nerve against the margin of the optic foramen. The successful transsphenoidal operations were in cases of this clinical type, and it is assumed that the tumour had shifted in position sufficiently, after the sellar decompression, to release the compressed optic tract and so bring about an improvement in vision with recovery in the blind homonymous fields.

These patients did not show any clinical evidence of a massive intracranial extension or of increased intracranial pressure. The transfrontal approach does not give satisfactory access in these cases, as the restricted prechiasmal space makes it difficult to dislodge the tumour forwards from under the side of the chiasma unless the more seriously affected optic nerve is sacrificed, which is undesirable. It is suggested, therefore, that when this type of homonymous hemianopia is present, a better result is likely to be obtained by the transsphenoidal operation.

The other type of homonymous hemianopia, namely that due to involvement of the supranuclear optic radiation, is produced by an extension of the adenoma laterally into the middle cranial fossa. This extension may be so large as almost to fill the temporal fossa. The visual fields in these cases frequently show incomplete homonymous defects with a quadrant or sector remaining, which is

always in the lower field, and the central vision is good and is about the same in both eyes. There are usually, but not always, unmistakable clinical manifestations of these large intracranial extensions, such as epilepsy, olfactory hallucinations, hemiparesis, severe headaches; and occasionally papillœdema is superimposed on the atrophic optic disks. Cases of this type, as might be expected, have shown little or no improvement after a transsphenoidal operation, and sooner or later the symptoms of intracerebral damage progressed; in two instances death occurred suddenly within a few days after operation from the effects of the extension. Neither did a transfrontal operation alone give more than a partial relief of symptoms. The ideal procedure is to demonstrate the position and the size of the extension by ventriculography, and then to remove it through a lateral flap after incising the temporal cortex.

The following example, previously reported by Dr. Cushing (1932, p. 77),[10] deserves recording again, along with the ventriculogram, which shows how a large temporal lobe extension was found and removed despite the absence of conspicuous clinical signs.

Case 6.—C. E. C., aged 41 years, a salesman (P.B.B.H. Surg. No. 37497), was admitted on *Oct.* 21, 1930. His only complaints were slight failure of memory, lassitude, and a little blurring in the right half of the field of vision which he had noticed for about six months. There had been a rapid increase of about 20 lb. in weight two years previously.

Examination showed a healthy-looking man with a right upper quadrantal homonymous hemianopia (*Fig.* 596). There was only slight lowering of visual acuity, and slight pallor of the optic disks. The radiograph revealed a widely ballooned sella (23 × 34 mm.). There was no aphasia.

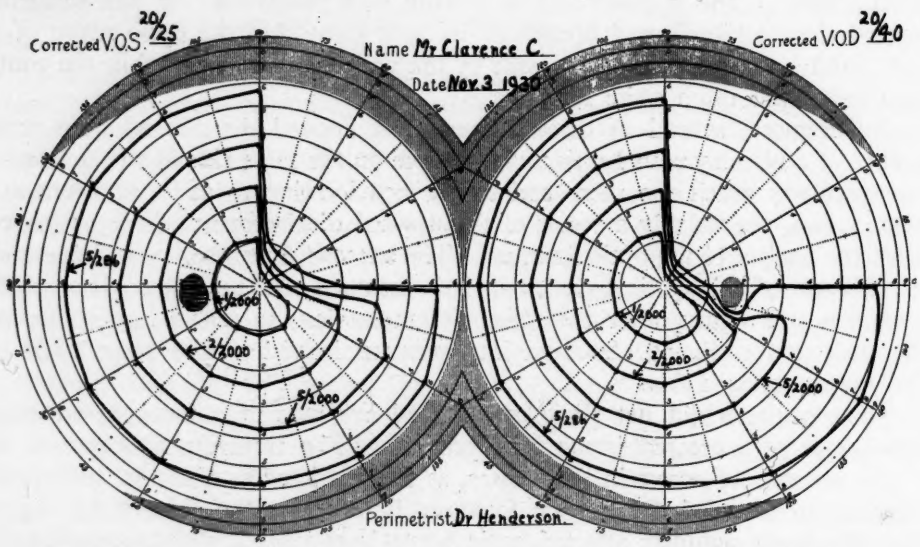


FIG. 596.—*Case* 6. Pre-operative fields of vision showing right upper quadrantal homonymous hemianopia with relatively good central vision in both eyes, indicating involvement of the lower left optic radiation. There was a large extension of the adenoma into the temporal lobe. Compare with *Figs.* 595, 600, and 602.

On *Nov.* 4, 1930, a right transfrontal exploration was made and the intrasellar portion of the adenoma was sucked out in the usual way. The optic nerves, which did not appear to have been subjected to any pressure by the tumour, were quite free and there was no visible evidence of tumour extension to the left of the chiasma to explain the homonymous field defects.

As no improvement followed the operation ventriculography was employed to check the diagnosis. This showed (*Fig.* 597) a sharply demarcated obliteration of most of the left temporal horn, with the third ventricle slightly displaced upwards and to the right. A left

FIG. 597.—*Case* 6. Ventriculogram. Note widely ballooned sella and obliteration of the anterior two-thirds of the left temporal horn due to a large temporal extension of the adenoma. The size of the extension is indicated by the indented expansion of the temporal horn which surrounded its posterior end. Arrows point to the slightly elevated floor of the third ventricle. Note the bone-flap of the previous transfrontal operation with three silver clips at its base.

lateral osteoplastic exploration was made on the same day (*Nov.* 28, 1930), and when the temporal lobe was incised a large adenomatous tumour was exposed. The well-defined capsule was incised and its soft reddish contents evacuated by suction. The sac of the extension, which was easily separated from the brain, was then drawn out and electrically amputated across its neck in the region of the sella (*Fig.* 598).

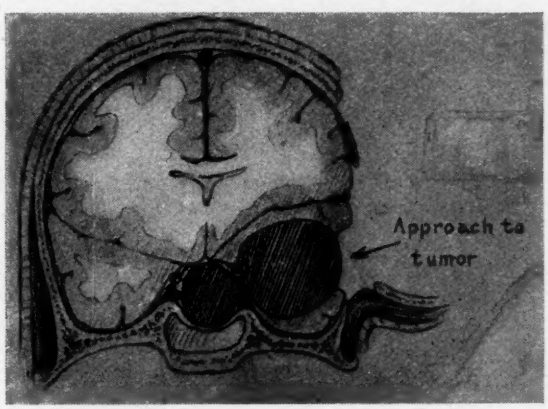


FIG. 598.—*Case* 6. Diagrammatic sketch to show position of the temporal extension and its exposure through a secondary lateral osteoplastic flap.

This operation was followed by temporary aphasia, and, although the quadrantal hemianopia remained unchanged, there was some improvement in the visual acuity. He never received X-ray treatment. At the present time, six years after operation, he states that he is in good health and has had no further trouble with vision.*

* A later report states that he died on November 26, 1938, following reoperation for recurrence of symptoms.

COMMENT.—This was the first time that an extension of a pituitary adenoma into the temporal lobe had been demonstrated with the aid of ventriculography and deliberately attacked. The necessity of having to transect the left temporal lobe, however, resulted in just enough residual speech disturbance to prevent the patient resuming his former occupation as a salesman, so that the outcome has been recorded as only a 'moderate' one. Other cases with similar extensions, especially on the right side, have since been treated with greater success.

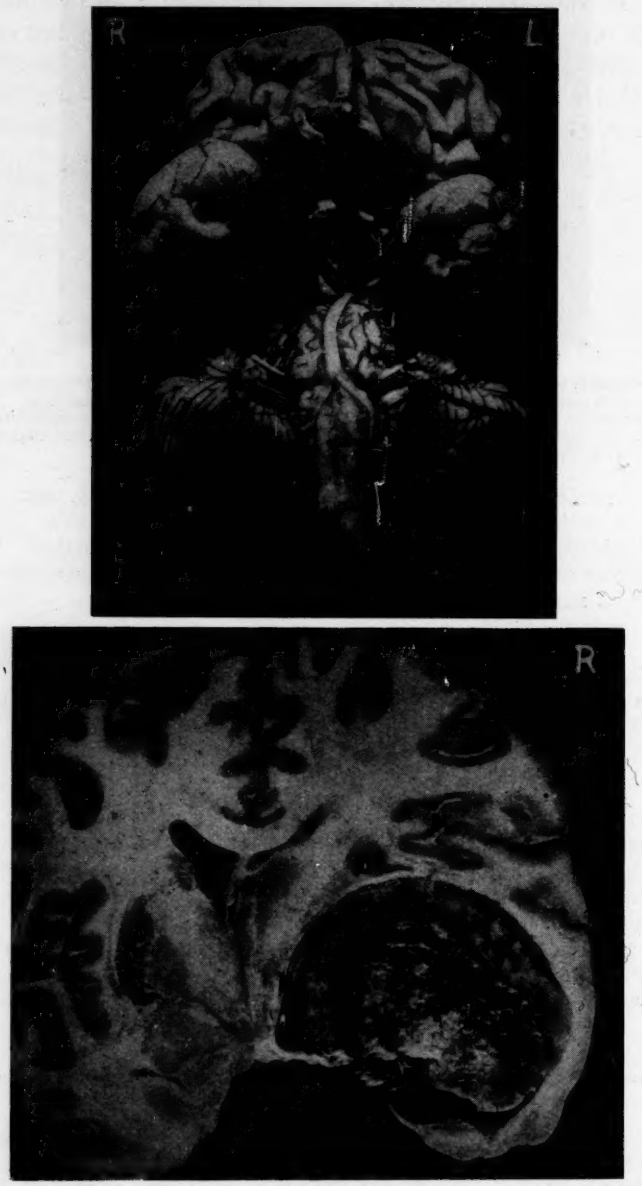


FIG. 599.—A large unsuspected and symptomless extension of a pituitary adenoma (acidophil) into the right temporal lobe. Note (*above*) the broken neck of the tumour passing below and lateral to the chiasma, which, though distorted, produced no visual defects. Note (*below*) how large the temporal extension may become without producing homonymous hemianopia. (*From Cushing and Davidoff*, 1927.)

In addition to showing an unexpectedly large extension into the temporal lobe, the ventriculograms are also of interest in that there was only the slightest displacement of the third ventricle to the right and upwards; it was, in fact, much less than is usually found in association with temporal lobe gliomas or other middle fossa tumours. The absence of ventriculographic evidence of a large mass in the region of the optic tract at the lower boundary of the third ventricle supports the belief, which is also based on post-mortem findings, that some of these lateral extensions escape from the sella through a narrow neck below the chiasma, and then spread out into the temporal lobe; a process that may be compared to the extension of a collar-stud abscess.

That the tumour can escape from the sella in this manner without causing sufficient displacement of the chiasma and tract to produce any visual defects is shown by a specimen (*Fig.* 599) from a patient with acromegaly in whom the visual acuity and fields were normal, and by another specimen (cf. *Fig.* 622) from a somewhat similar case with a chromophobe adenoma. It may be assumed, therefore, that the incomplete homonymous hemianopia which is characteristic of a temporal lobe extension is due to partial involvement of the loop of the optic radiation, and that the absence of a central scotoma in the ipsilateral eye indicates that the side of the chiasma (with the optic nerve and tract) has not been grossly distorted by the neck of the tumour.

It is usual, however, for these large temporal-lobe extensions to produce characteristic clinical manifestations. The cystic extension into the temporal lobe in *Case* 24 (cf. *Fig.* 635), for example, had produced such unmistakable evidence of a temporal lobe tumour that its intrasellar origin was unsuspected. It may be mentioned that pituitary tumours occasionally extend also into the frontal lobe, and, after localization by ventriculography, may be encountered during operation for a presumed glioma.

For comparison with *Case* 6, the history of another patient with homonymous hemianopia who happened to be in hospital about the same time may be briefly recorded.

Case 7.—P. H. M., aged 51 years, a real estate agent (P.B.B.H. Surg. No. 37284), was admitted on *Sept.* 15, 1930. His symptoms had started only eight weeks previously and consisted of failure of vision, lassitude, somnolence, failure of memory, slight headache, and behaviour changes.

On examination, the only signs were complete left homonymous hemianopia with poor vision in both eyes (*Fig.* 600) and very doubtful early primary atrophy of the optic disks. The sella was not definitely enlarged (13 × 13 mm.), although the right half of its floor was depressed, giving a double contour in the lateral radiograph.

On *Sept.* 26, 1930, ventriculograms were made as there was some uncertainty about the situation of the lesion. These showed a well-marked localized displacement of the lower part of the third ventricle to the left (*Fig.* 601), indicating a paramedian suprasellar tumour; there was no deformity of the temporal horns or bodies of the lateral ventricles. A right transfrontal exploration was carried out on the same day. This disclosed a small suprasellar adenoma which was excavated by suction through the prechiasmal space; no extension could be seen to account for the homonymous hemianopia.

His general condition improved considerably after operation, and the somnolence disappeared. The *homonymous* hemianopia became transformed into a nearly complete *bitemporal* hemianopia (*Fig.* 602). There was a marked improvement in the visual acuity, and later on a wide expansion of both temporal fields occurred. Owing to slight residual

mental changes he was unable to return to full work, so that the success of the operation, as in the last case, is recorded as only 'moderate'.

The somnolence recurred fifteen months later, together with aggravation of the mental symptoms and failure of vision in the right eye. Further ventriculograms showed normal,

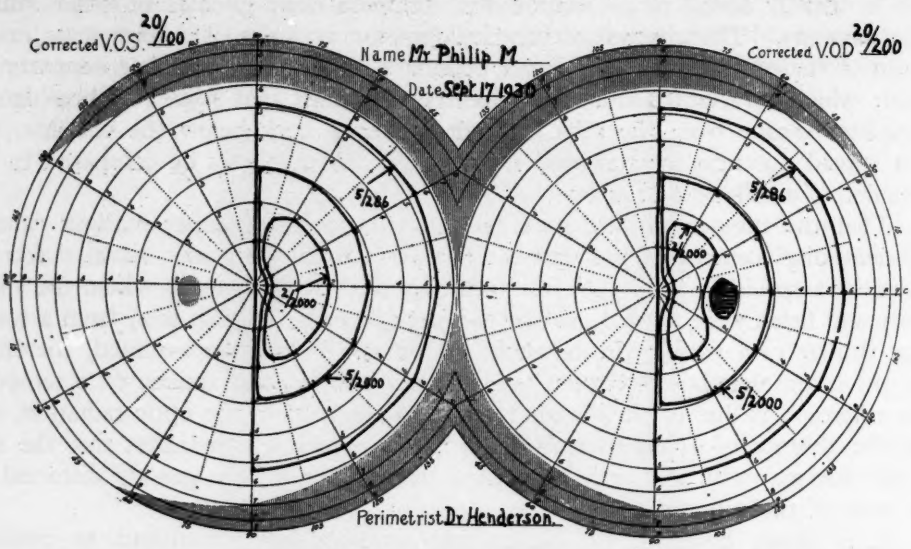


FIG. 600.—*Case* 7. Visual fields prior to operation, showing homonymous hemianopia.

FIG. 601.—*Case* 7. Ventriculogram. Note localized displacement (arrows) of lower part of third ventricle to the left by a suprasellar adenoma which had produced homonymous hemianopia by involvement of the optic tract.

undeformed lateral ventricles, but there was complete absence of air in the third ventricle, indicating an upward median extension of the tumour. Nothing further was done. Progressive mental deterioration and general weakness preceded his death two years after the operation.

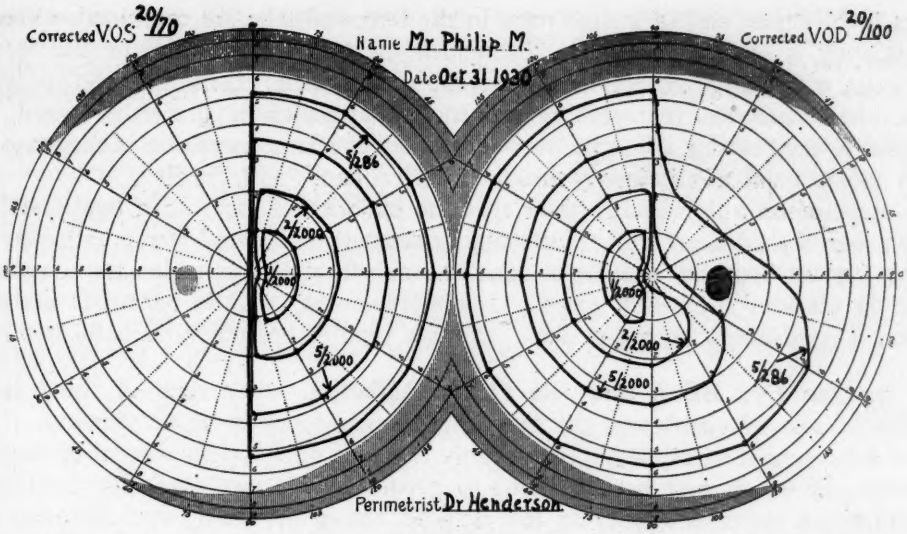


FIG. 602.—*Case* 7. Post-operative fields showing shift from homonymous (cf. *Fig.* 600) to bitempora defects after the excavation of a suprasellar adenoma implicating the left optic tract.

COMMENT.—The chief point of interest in this case is the immediate post-operative change in the type of visual field defect from a complete homonymous to a complete bitemporal hemianopia. An equally striking alteration in the type of hemianopia was observed after operation in three other cases, but in all of them it was a bitemporal hemianopia which became transformed into a homonymous hemianopia.

In one instance a complete bitemporal hemianopia with a visual acuity of 20/50 in both eyes was transformed immediately after the radical excavation of an adenoma from beneath an intact diaphragma sellæ, into a complete homonymous hemianopia without altering the visual acuity. The change in this case was attributed to a post-operative clot, which necessitated re-elevation of the flap, forming around the chiasma; the eye on the same side as the affected optic tract gradually became blind during the next month, whereas the visual acuity in the other eye has now remained unchanged for nearly seven years.

In the other two cases the change in the visual fields did not occur while the patient was in hospital, but was first noticed, along with an improvement in the visual acuity, at a subsequent examination some months later, after a course of post-operative X-ray treatment (one of the patients had had a transsphenoidal operation). The change in the last two cases was not immediately related to the operation and may have been due to the tumour breaking through its confines laterally and backwards and impingeing on the optic tract, the compression of the optic chiasma being at the same time relieved. Similar cases in which an early or incomplete bitemporal hemianopia gradually and spontaneously became homonymous in type, without operation, have been recorded by Walker and Cushing[28] and by Traquair[25]. The importance of the reverse change in *Case* 7, however, is that the primary visual defect must have been due to compression of the optic tract and not of the optic radiation in the temporal lobe.

SUMMARY OF GROUP 2.—It is important to recognize the *two clinical types of homonymous hemianopia*, although in some of the less clear-cut cases the effects of

tract involvement and of a large mass in the temporal lobe are combined. Ventriculography is often necessary to distinguish the two varieties and to indicate, in the cases with a large intracerebral mass, the most suitable position for the operation flap. It is believed that the transsphenoidal approach is preferable when the tumour is compressing the optic tract only, whereas a large extension in the temporal lobe should be attacked directly through a lateral flap.

Experience will probably show that the majority of cases with temporal lobe extensions should have both transfrontal (chiasmal) and lateral (temporal) explorations, just as both the transventricular and sub-frontal approaches are sometimes used in cases of suprasellar cysts (craniopharyngioma). Little benefit is likely to follow a transfrontal operation alone in either type of homonymous hemianopia.

3. One Eye Blind and the Other Affected.—In several of these cases, advanced loss of vision was the only clinical manifestation of the tumour. The field defects, in such instances, presumably began as a fairly symmetrical bitemporal hemianopia which had been allowed to progress with loss of acuity until little useful vision remained (generally less than 20/200 in the seeing eye, the other eye having become blind only a short time previously). There was no reason in these cases to suspect an intracranial extension of the adenoma, but operation produced little or no improvement in vision as the chiasma and nerves had almost certainly been permanently damaged by prolonged compression. The visual deterioration was, however, usually arrested and the patients continued to live for many years in good general health with preservation of what little eyesight still remained. Cases of this kind clearly show the importance of not delaying operation once the presence of a pituitary tumour or a progressive visual field defect has been established.

Most of the patients with unilateral blindness gave symptomatic evidence of an intracranial extension of the adenoma, which had destroyed one optic nerve, while the contralateral, more recently affected eye still retained relatively good central vision (this manner of extension is well shown in *Fig.* 606). Operation was sometimes followed by temporary improvement in the vision of the seeing eye, but the symptoms of the intracerebral portion of the tumour, the radical removal of which was rarely possible, eventually progressed and death ensued within a few years. In some cases, these symptoms progressed within six months of the operation, which has, therefore, been counted a failure, even though vision was in some instances improved. The following is a typical example of the cases in this group :—

Case 8.—J. F. G., aged 30 years, a butcher (P.B.B.H. Surg. No. 37967), was admitted on *Jan.* 7, 1931, with the complaint of failing vision in the only seeing eye.

Five years before admission he accidentally discovered a marked loss of vision in the left eye, but he never observed any hemianopia. The eye became blind within one year. There was an increase of 25 lb. in weight about that time.

His general health was good and there was no further change in vision until six months before admission, when he noticed an early progressive defect in the temporal field of the right eye ; there was also slight pain in the right eye, but no headaches. For the preceding two months there had been occasional nausea and vomiting, unsteadiness on his feet, and transient attacks of dizziness.

Operation was advised several times during these five years, but he refused it as long as the right eye remained good. He had received no X-ray treatment and was in good general health and showed no mental changes.

EXAMINATION.—The sense of smell was considerably impaired on both sides, more especially the left. The optic disks showed advanced primary atrophy in the left eye, and on the right there was a superimposed œdema of one dioptre. V.O.D. 20/70 with complete temporal hemianopia; the left eye was blind (*Fig.* 603). There was slight proptosis of both eyes, especially the left, and early pyramidal signs as shown by considerable right lower facial weakness, slight weakness of the right hand, absent right abdominal reflexes and an equivocal right plantar response; there was also slight ataxia of the right arm. X-ray examination showed a moderately enlarged sella (18 × 25 mm.), and complete erosion of the left anterior clinoid process.

On *Jan.* 16, 1931, ventriculograms were made to outline the postition and size of the presumed intracranial extension; they showed that the anterior horns of the lateral ventricles were separated by the upper end of a large mass which was projecting upwards from the region of the sella, indicating clearly the large size of the tumour (*Fig.* 604). A right transfrontal exploration with subtemporal decompression was carried out on the same day. The

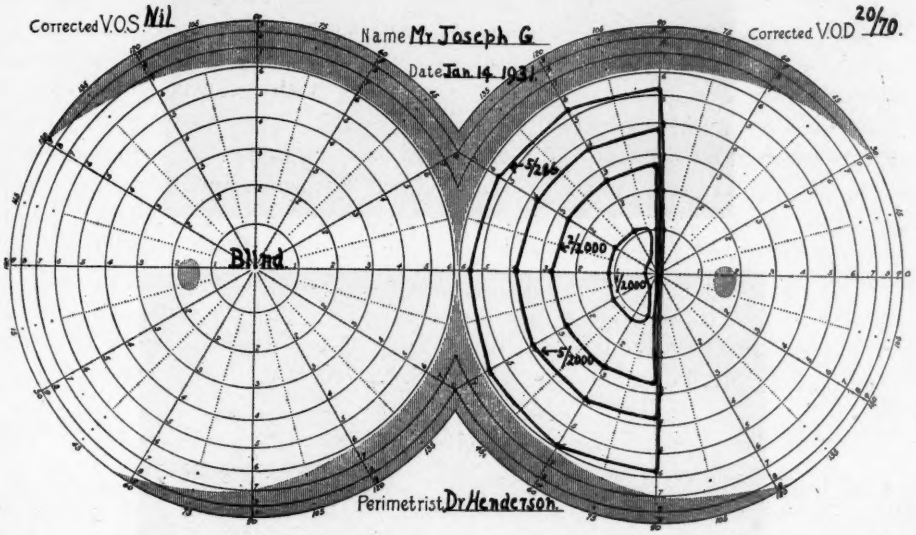


FIG. 603.—*Case* 8. The visual chart before operation of a patient with a large suprasellar extension which had produced blindness in the left eye four years previously.

right optic nerve was stretched far out to the right side of the huge tumour, which extended upwards into the base of the brain. The left optic nerve and chiasma were not seen. The tumour, which was tough and extremely vascular, was partially excavated on its anterior surface. Convalescence was uneventful apart from some drowsiness during the first two days. He had a course of four X-ray treatments.

There was no improvement in vision, but he was able to do a little work. After twelve months he became very apathetic and drowsy, and the mental deterioration became so marked that he was confined to bed and eventually died two years after operation.

COMMENT.—The ventriculogram clearly shows the large size that may be attained by an upward extension of a slowly growing chromophobe adenoma. The intracranial symptoms, although unmistakable, were late in appearing and were associated with much less general disability and mental disturbance than might have been expected with a tumour in this situation. The attempted removal of such a growth, even should it prove to be encapsulated and easily separable from the brain substance, would be so hazardous that recourse must be had to irradiation in the hope that it will react favourably.

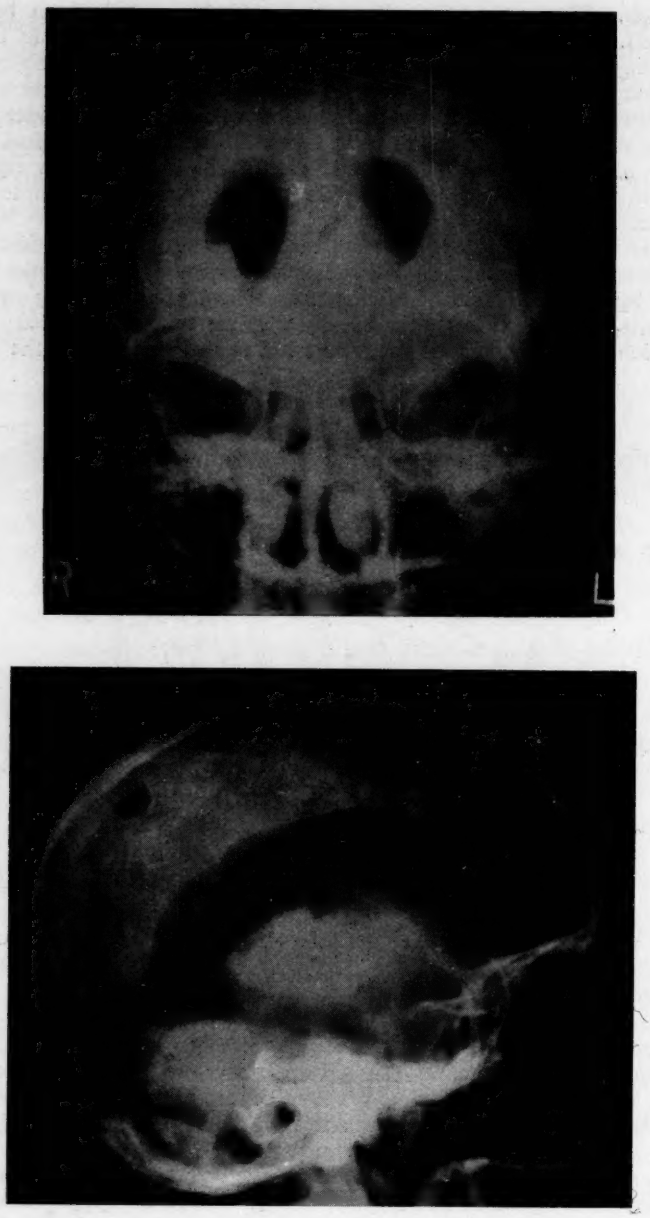


FIG. 604.—*Case* 8. Note (*above*) separation of the anterior horns of the lateral ventricles by the dome of a large upward extension of a chromophobe adenoma, which is seen (*below*) projecting into the floor of the dilated left ventricle.

The next case illustrates a somewhat different direction of tumour extension and shows how central vision of the good eye may be preserved, even though the other eye has become blind.

Case 9.—A. E. S., a schoolgirl, aged 18 years (P.B.B.H. Surg. No. 41559), was admitted on *July* 18, 1932, with the complaint of failing eyesight and weakness of the left side.

For one year she had observed failure of vision in the right eye without noticeable limitation of the visual field, occasional hallucinations of smell, a slowly progressive left

hemiparesis, affecting first the arm and then the leg, and frequent vomiting. During the last few months before admission there had also been occasional headaches, beginning failure of vision in the left eye, lassitude, and inability to concentrate. She had ceased growing at the age of 12 years and had never menstruated.

EXAMINATION.—She was a poorly developed young woman. Both optic disks showed primary atrophy; the left eye had an acuity of 20/40 with complete temporal hemianopia, and the right eye was blind (*Fig.* 605). There was marked impairment of the sense of smell on the right side, slight proptosis of the right eye, and slight left hemiparesis. X-ray examination showed a moderate enlargement of the sella (15 × 21 mm.), especially on its right side, and the pointed right anterior clinoid was displaced upwards.

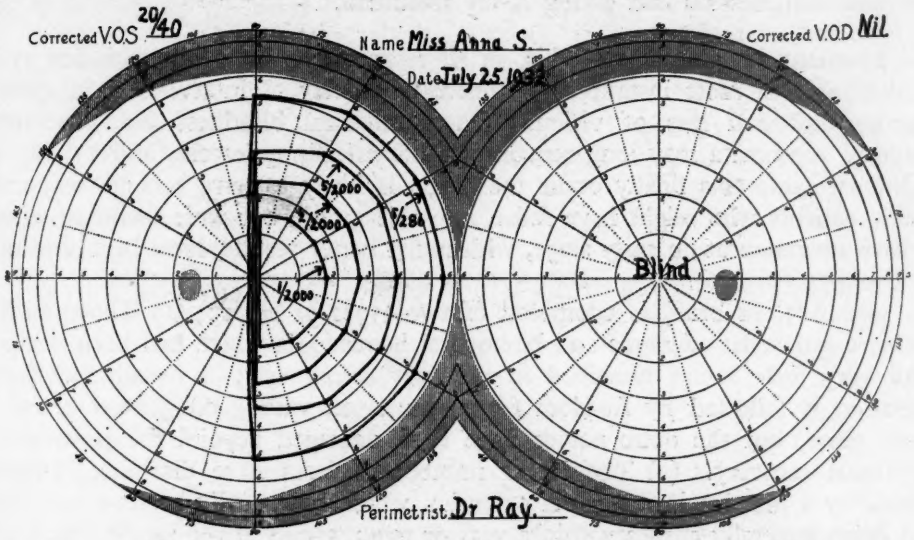


FIG. 605.—*Case* 9. The visual chart before operation, showing good central vision in the left eye of a patient with an advanced intracranial extension on the right side.

On *July* 27, 1932, the usual right transfrontal exploration was made, but the brain was very tight and the optic nerves could not be adequately exposed until the dilated right ventricle had been tapped. The right nerve was pushed upwards by the underlying tumour (*Fig.* 606). Masses of tumour were dislodged and removed largely by suction from the Sylvian region and from under the chiasma.

FIG. 606.—*Case* 9. Operative sketches showing: I, Right optic nerve displaced upwards by an extrasellar extension of the adenoma; II, Left optic nerve, brought into view after tapping the ventricle to obtain adequate exposure; III, Dislodgement of tumour extension from Sylvian region, exposing vessels.

The operation was followed by slight improvement in vision with a return of 20/200 in the temporal field of the blind right eye, so that originally the hemianopia was probably homonymous in type. The hemiparesis persisted, however, and headaches and vomiting returned in a few months. She died two and a quarter years later. No X-ray treatment was given. She has been recorded as a 'progressive deterioration' case.

COMMENT.—This story is typical of the cases in this group which did badly after operation. A large mass of tumour probably remained in the right Sylvian cleft and nothing of permanent value was accomplished by the operation. Occasionally such a tumour may lie sufficiently far forward to justify a frontal lobectomy as practised in cases of sphenoid ridge meningioma; in this particular instance it was too far back, for only the anterior part could be seen in the Sylvian cleft. The results have shown that anything approaching a radical removal is impracticable under the circumstances and that reliance must be placed on relieving the optic compression and giving X-ray treatment.

SUMMARY OF GROUP 3.—This, in all respects the most disappointing group, is ascribable in most instances to unnecessary delay of intervention in cases of obscure unilateral loss of vision. Once unilateral blindness has supervened, pituitary adenomata may long remain symptomatically quiescent, and by the time additional symptoms finally occur the lesion is likely to have become inoperable. A few patients who might have fallen into this group, but were fortunate enough to have operation at an early stage, with much better results, have been assembled in Group 5 (p. 856).

Group 3, in brief, is composed of two types of cases: (1) Those with an ordinary intrasellar adenoma and bitemporal hemianopia which had been neglected until very little vision remained in the only seeing eye; a usually satisfactory operation is followed by freedom from symptoms, with good general health for many years, but the optic nerves have been damaged beyond the possibility of functional recovery. (2) The larger number of cases have disabling symptoms caused by a massive intracerebral extension which has usually become inoperable, and death generally ensues within a year or two; vision in the seeing eye is often relatively good.

4. Central Scotoma or Inferior Quadrantal Defects.—The visual fields of the cases in this group are schematically shown in *Fig.* 607. The majority of the patients had transsphenoidal operations, so that the following remarks concerning the probable mechanism of these uncommon field defects are based entirely upon the conditions observed in the few patients who had transfrontal operations, on the post-mortem findings in one case which showed that the tumour extended upwards behind the chiasma, and by analogy with other tumours in the same region, especially the craniopharyngiomas.

a. Bilateral Central Scotomata.—There were 6 patients with a marked central scotoma in both eyes (*Fig.* 607, A); 2 of them had transfrontal operations and the chiasma was prefixed in both (1 died after operation). Cushing[9] and others have drawn attention to the frequent occurrence of a scotomatous instead of a hemianopic field defect with retrochiasmal tumours, especially those of hypophysial duct origin. Many of these tumours arise near the upper end of the pituitary stalk, and therefore impinge on the posterior margin of the chiasma, where the macular bundles are situated, and push it forwards into the sulcus chiasmatis; the visual fields in such cases commonly show central scotomata.

Pituitary tumours, on the other hand, arise below and usually rather in front of the chiasma, so that the upper end of an expanding adenoma cannot primarily affect its posterior aspect except when it already occupies a prefixed position

(cf. *Fig.* 608) and lies in the sulcus chiasmatis. This anatomical variation according to de Schweinitz (1923)[22] occurs normally in about 5 per cent of people. When the chiasma is prefixed a pituitary tumour usually extends upwards behind it and

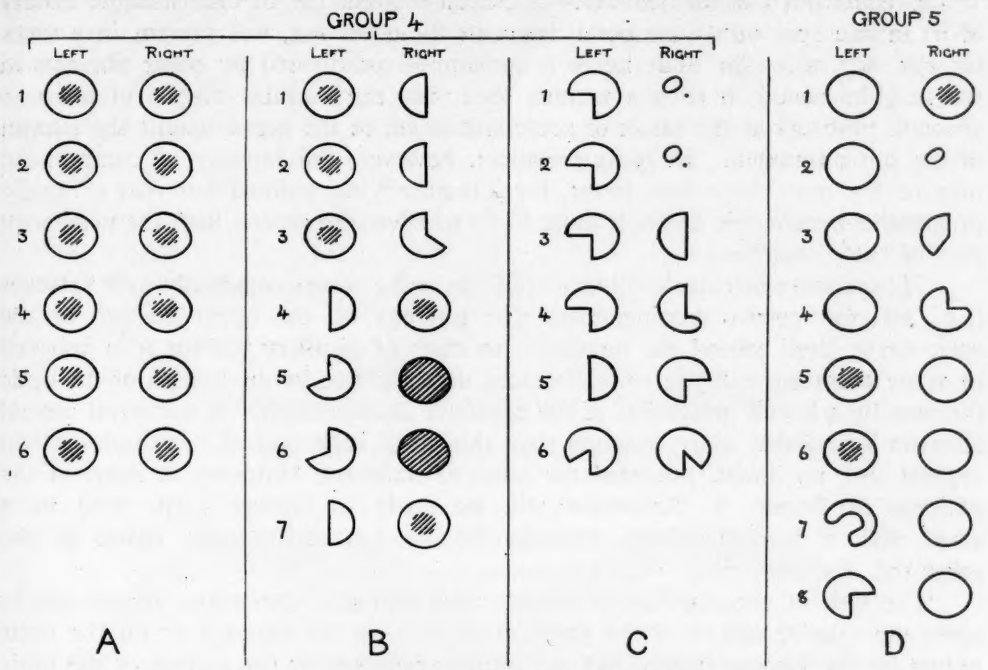


FIG. 607.—Diagrammatic representation of the visual fields of the cases in Groups 4 and 5: A, Bilateral central scotomata; B, Unilateral central scotoma, with temporal hemianopia in the other eye; C, Inferior temporal quadrantal defect in one or both eyes; D, Only one eye affected.

commonly produces central scotomata. The facts available from the few cases in this group support the suggestion that marked central defects indicate a prefixed chiasma with little or no space available in front of it through which to reach the tumour during a transfrontal exploration.

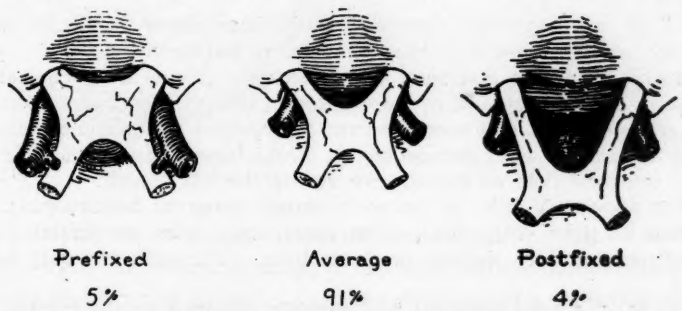


FIG. 608.—To show the three principal types of chiasma (*after Schaeffer*).

Whether this be so or not, the important point is the recognition of a progressive central scotoma as one of the types of visual field defect in cases of pituitary adenoma, more especially as there may be little or no pallor of the optic disks and no enlargement of the sella. The demonstration of scotomata requires

more careful perimetry than is the case with peripheral defects. Finally, it may be added that a prefixed chiasma is seldom encountered during transfrontal operations in cases with bitemporal hemianopia.

b. Unilateral Central Scotoma.—A central scotoma (or an unmistakable history of it) in one eye, with a temporal defect in the other eye, was present in 7 cases (cf. *Fig.* 607, B). The optic nerve is sometimes compressed by other tumours in the neighbourhood in such a manner that only the macular bundle of fibres is affected, probably as the result of acute angulation of the nerve against the margin of the optic foramen. In some instances, however, the rapidity of compression may be the more important factor, for Traquair[25] has pointed out that a rapidly progressive hemianopic defect is more likely to affect the central than the peripheral part of the visual field.

This primary macular involvement of one nerve occurs commonly with tumours (e.g., olfactory groove meningiomas) that impinge on the upper surface of the optic nerve close behind the foramen; in cases of pituitary tumour it is believed to occur when the optic nerve is displaced upwards against the margin of the optic foramen by a lateral protrusion of the adenoma underneath it. A unilateral central scotoma is probably more common than this small collection of 7 examples would suggest and, no doubt, preceded the onset of unilateral blindness in many of the patients in Group 3. Reference will be made in Group 5 (p. 856) to 3 cases with a marked central scotoma in one eye and normal vision in the other (cf. *Fig.* 607, D).

The type of visual defect in patients with pituitary adenomata depends chiefly upon the relative effects of the pressure exerted on the chiasma or on the optic nerves by the tumour below, and the counter-pressure by the margin of the optic foramen or the anterior cerebral artery above. A central scotoma may, therefore, enter largely into the field defect in cases of bitemporal hemianopia when the visual loss in the two eyes is asymmetrical, as shown, for example, by the fields (*Fig.* 588) and operative sketch (*Fig.* 589) in *Case* 3.

An excellent visual recovery which has been maintained for 21 years after a transsphenoidal operation on a patient who had a central scotoma in one eye is illustrated by the plotted fields of vision in the following case report.

Case 10.—I. H., aged 33 years, a professional billiards player (P.B.B.H. Surg. No. 3781), was admitted on *Oct.* 29, 1915, with the complaint of failing vision.

For about one year there had been occasional right frontal headaches and during that time a progressive failure of vision in the right eye, due to a central scotoma without any defect in the peripheral field, had been observed by repeated perimetric examinations; vision in this eye was reduced to light perception six weeks before admission. He had noticed a haziness in the temporal field of the left eye during the last month.

Examination showed V.O.S. 20/30 with partial temporal hemianopia; V.O.D. occasional perception of light (*Fig.* 609). The optic disks were moderately atrophic. The right pupil still reacted very slightly to direct light. The sella was only slightly enlarged (15 × 10 mm.).

On *Nov.* 6, 1915, a solid adenoma was partially removed by the transsphenoidal route. There was an immediate recovery of vision in the blind right eye to 20/20 within four days after operation (*Fig.* 610), and the visual fields two weeks later showed complete recovery except for an inferior nasal quadrantal defect in the right eye which has persisted ever since. He never had X-ray treatment.

He wrote on *Nov.* 19, 1936, to say that his general health and vision have remained perfect since the operation twenty-one years previously; this was confirmed by Dr. W. P. Parker, of Detroit, who examined his visual fields on *Nov.* 27, 1936.

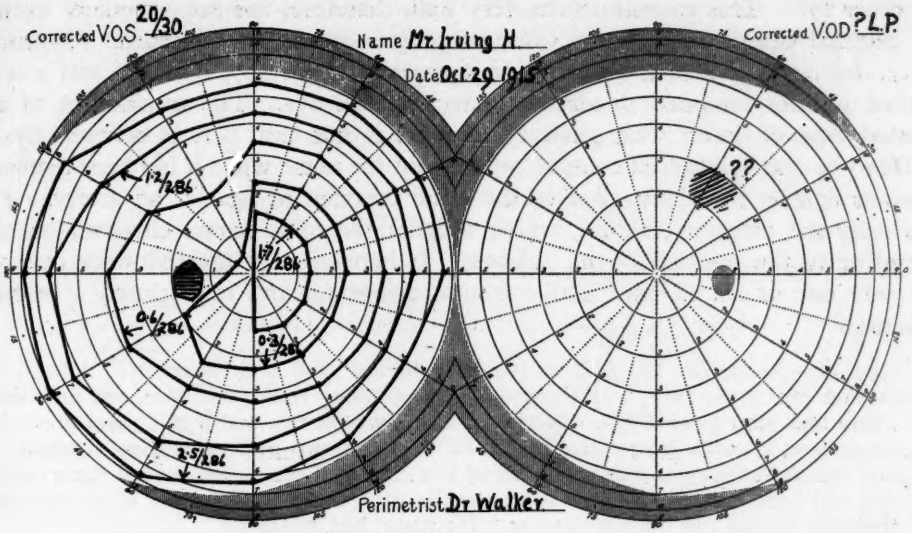


FIG. 609.—*Case* 10. Pre-operative fields of vision.

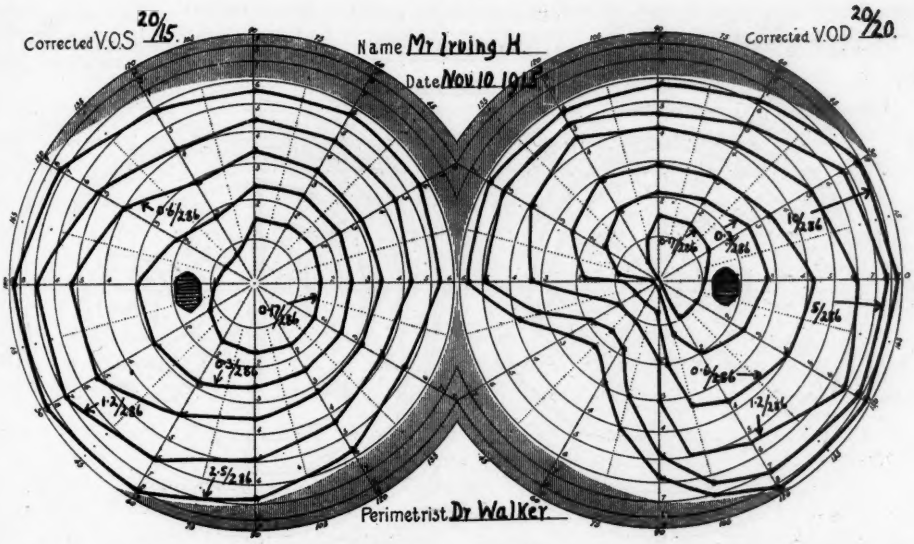


FIG. 610.—*Case* 10. Visual fields four days after a transsphenoidal operation, showing the rapid and almost complete recovery in the virtually blind right eye.

COMMENT.—The most striking and complete visual recovery was often obtained in cases of this kind (cf. fields of *Case* 3) in which there had been a rapidly progressive scotomatous type of defect. It is noteworthy that, as in *Case* 1, the partial removal of a solid tumour from below, without subsequent X-ray treatment, has not been followed by any symptomatic recurrence over a period of so many years.

It is difficult to imagine an occupation which would reveal so promptly the slightest defect of vision, and especially central vision, in the right eye as that of a professional billiards player. The sella was not widely expanded and it is significant that the operation took place only when a beginning temporal defect appeared in

the other eye. This case illustrates very well, therefore, the importance of excluding external compression as the cause of progressive unilateral central scotoma.

c. Inferior Quadrantal Defects.—In 6 cases (cf. *Fig.* 607, C) there was a well-marked inferior temporal quadrantal defect in one eye. The mechanism of this unusual type of defect with pituitary tumours is not clear; it is believed by the writer to be due to localized counter-pressure on the nerve when it has been displaced upwards against the sharp edge of the optic foramen or against an artery. This is usually the anterior cerebral, which overlies the optic nerve, chiasma, or tract according to the position of the chiasma. It happens that the following case was the only one of six to have a transfrontal operation, and it disclosed a prefixed chiasma.

Case 11.—Alexander B., aged 22 years, a bottler (P.B.B.H. Surg. No. 40802), was admitted on *March* 21, 1932, with the complaints of failing vision, lassitude, and drowsiness.

There had been a rapid gain of about 30 lb. in weight two and a half years previously. He had noticed a slowly progressive failure of vision for two years, involving especially the temporal fields of both eyes, with a more rapid loss in the left eye during the last three months. Diplopia had been present for about three months at the onset. There was some drowsiness and lassitude during the last six months. He never had headache.

Examination revealed bilateral primary atrophy with V.O.S. 20/200 and V.O.D. 20/25. The visual fields (*Fig.* 611) showed an inferior temporal quadrantal defect in the left eye,

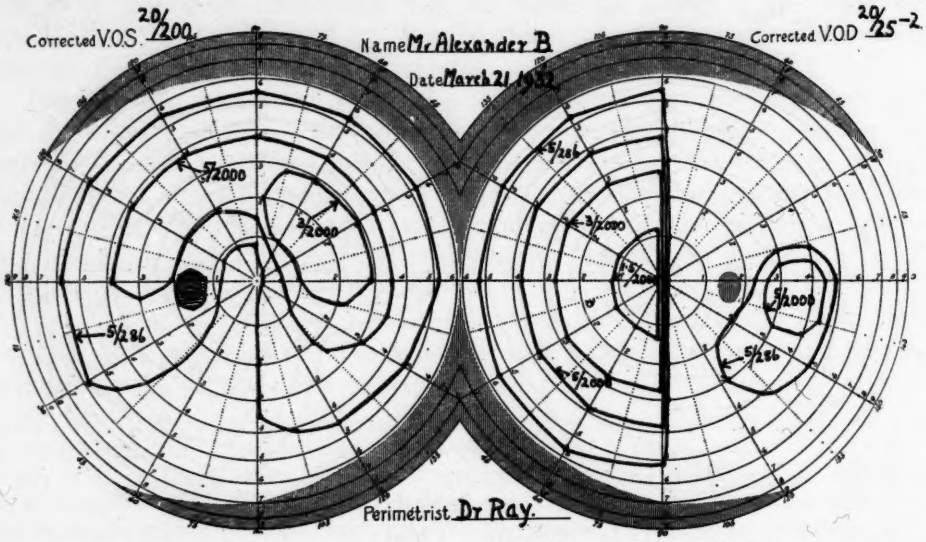


FIG. 611.—*Case* 11. Pre-operative fields of vision showing an inferior quadrantal defect in the left eye in a patient with a prefixed chiasma.

and a clean-cut temporal hemianopia with a small island of vision remaining in the temporal field of the right eye. The sella was considerably enlarged (23 × 21 mm.).

A right transfrontal exploration was made on *April* 1, 1932. The chiasma was found to be pushed forwards and upwards by a solid tumour which lay chiefly behind it (*Fig.* 612).

A small snip of tumour was taken from the situation shown in *Fig.* 612, I, for immediate examination by Dr. Eisenhardt, and it was found to be a chromophobe adenoma. The field was so restricted owing to the forward position of the chiasma that it was necessary to divide the right anterior cerebral artery; this gave better access to the retrochiasmal portion of the soft tumour, which was then easily excavated by suction.

Convalescence was uneventful. There were no polydipsia, somnolence, or other signs of hypothalamic disturbance, and before the patient was discharged vision had improved

to 20/50 in the left eye and 20/25 in the right eye, without, however, any essential change in the visual fields. He had a course of four X-ray treatments. When examined two months later, acuity of vision in both eyes was 20/25, but the inferior quadrantal defects were still

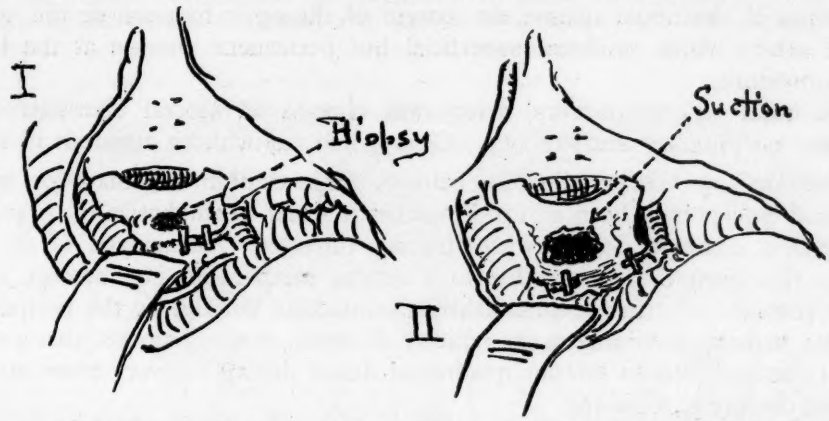


FIG. 612.—*Case* 11. Operative sketches showing: I, Tumour bulging upwards behind the prefixed chiasma—the site of biopsy is indicated; II, Shows opening through which the soft adenoma was excavated by suction behind the chiasma, and also the divided right anterior cerebral artery.

present (*Fig.* 613). He wrote in *October*, 1936, to say that he was in excellent health, doing full work, and that his vision had remained unchanged.* He had had only one course of X-ray treatment.

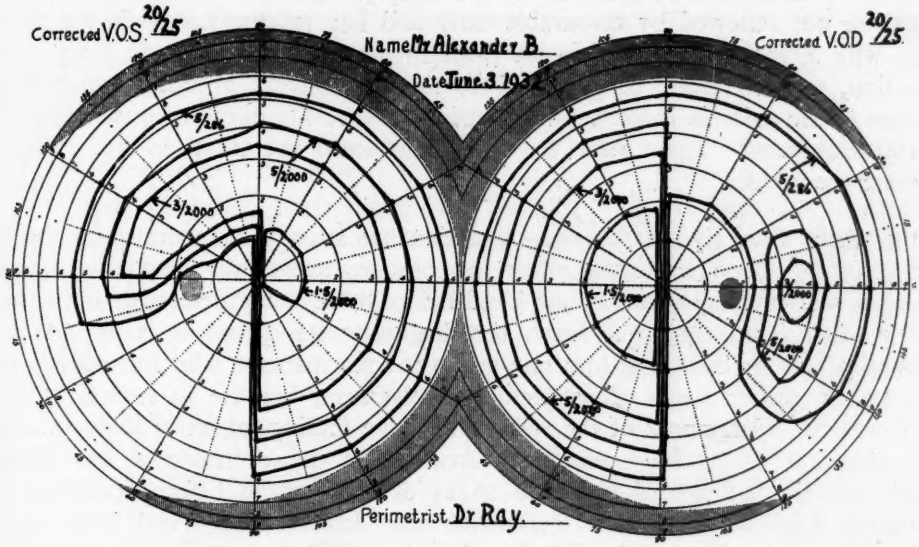


FIG. 613.—*Case* 11. Fields of vision two months after the transfrontal operation, showing slight expansion of the persistent inferior quadrantal defect, though there was a marked improvement in central vision, and a residual inferior defect in the right eye.

COMMENT.—The cases with an inferior quadrantal defect usually showed considerable improvement in visual acuity after operation, but rarely any expansion of the field into the blind lower quadrant. It is not clear why a lower quadrantal defect should not recover as readily as the more common upper quadrantal defects.

* He reported at New Haven on *Feb.* 10, 1938. No symptoms. V.O.S. 20/20; V.O.D. 20/20.

A possible explanation is that the upper quadrantal defects are most likely due to diffuse pressure by the tumour on the adjacent surface of the optic nerve or chiasma, whereas the lower defects are probably the result of a localized angulation or constriction of the nerve against the margin of the optic foramen or the anterior cerebral artery which produces superficial but permanent damage at the line of counter-pressure.

The right anterior cerebral artery was clipped on several occasions during operations on pituitary tumours (e.g., *Cases* 3 and 11) without apparent ill effects.

SUMMARY OF GROUP 4.—The patients with central scotomata or inferior quadrantal defects have been grouped together in order to emphasize the occurrence of these less common defects with pituitary tumours. An analysis of the cases suggests that both defects are due to a similar mechanism, i.e., damage due to counter-pressure affecting predominantly the macular bundles or the periphery of the nerve, or both, according to the rapidity of onset; it may be noted that a central scotoma changed into an inferior quadrantal defect during recovery after operation in several cases (e.g., *Case* 16).

When the disturbance is mainly unilateral it may be presumed that the optic nerve is displaced upwards by a lateral projection of the tumour, which is, therefore, more accessible by the transfrontal approach.

Bilateral defects, on the other hand, are believed to occur when the chiasma is prefixed and has been implicated by a tumour on its posterior aspect or has been elevated so that the short optic nerves are sharply angulated. The transsphenoidal operation was followed by favourable early and late results, just as it was in the cases with homonymous hemianopia from involvement of the optic tract. This operation, may therefore be preferred to the transfrontal approach when access in front of the chiasma is likely to be restricted, especially in the cases with bilateral central scotomata. There were too few transfrontal operations in this group to evaluate the results.

5. Only One Eye Affected.—Attention has already been drawn to the fact that pituitary adenomata often affect the eyes asymmetrically, and that in some instances one eye may even become blind before there is any detectable impairment in the other (e.g., *Case* 8). From the diagnostic standpoint it is important to emphasize this by collecting into one group the few patients who fortunately were seen in the earlier stages of monocular involvement, because in several of them there was no enlargement of the sella, a negative finding which is likely to dispel any suspicion of pituitary tumour. Occasionally the contralateral eye showed slight reduction of central vision to 20/25 or even 20/30 before operation, but perimetry disclosed no definite peripheral field defect. The visual fields in this group are schematically shown in *Fig.* 607, D.

In some instances the unilateral defect proved to be due to the extrusion of a small nodule of tumour through the diaphragma sellæ as is shown in the operation drawing of the following case, which has been previously recorded (Cushing, p. 73[10]).

Case 12.—H. F., aged 22 years, a salesman (P.B.B.H. Surg. No. 38756), was admitted on *May* 5, 1931, with the sole complaint of failing vision in the left eye of only three weeks' duration. The only clinical finding was a lower nasal quadrantal defect in the left eye (*Fig.* 614). The radiograph disclosed an expanded sella.

At operation on *May* 12, 1931, a small nodule of tumour was found projecting through the distended diaphragma sellæ underneath and partly enveloping the left optic nerve (*Fig.* 582). The nodule was easily removed after the soft intrasellar adenoma had been sucked out. At the conclusion of the operation it was found that the field defect had already disappeared, and he was discharged with completely normal vision. He received no X-ray treatment.

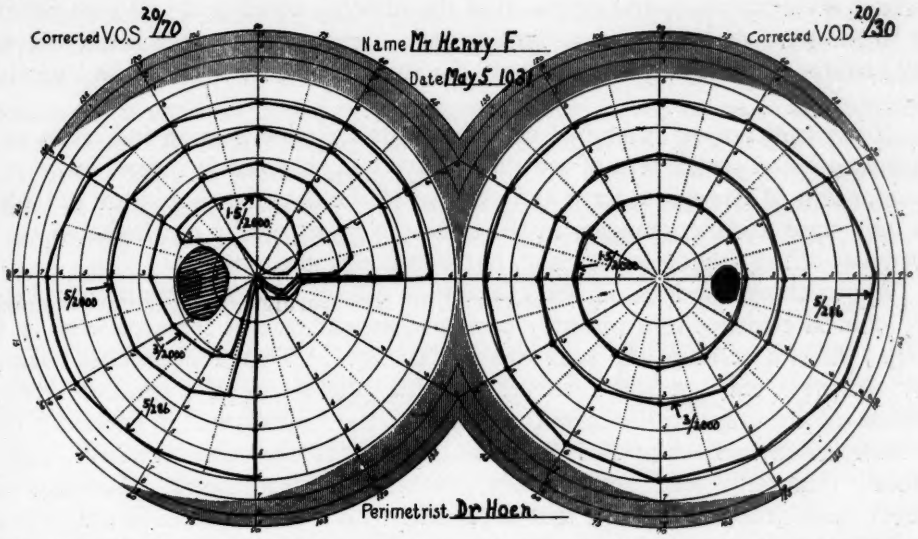


FIG. 614.—*Case* 12. Showing a lower quadrantal defect in the nasal field of the left eye before operation.

It was subsequently learned that he had a secondary transfrontal operation in another clinic during *February*, 1935, because of the appearance of a complete left temporal hemianopia three weeks previously, i.e., three and a half years after the first operation; the right eye was normal. He did well after the operation and when he last wrote in *October*, 1936, there had been no further trouble.

In other cases the diaphragma sellæ has been found intact, but a unilateral bulge or lateral protrusion of the tumour underneath it may be sufficiently localized to affect seriously one optic nerve, especially when the chiasma is post-fixed, without causing any functional disturbance of the other nerve. This is shown in *Fig.* 615, which illustrates what was found in a patient (P.B.B.H. Surg. No. 33916)

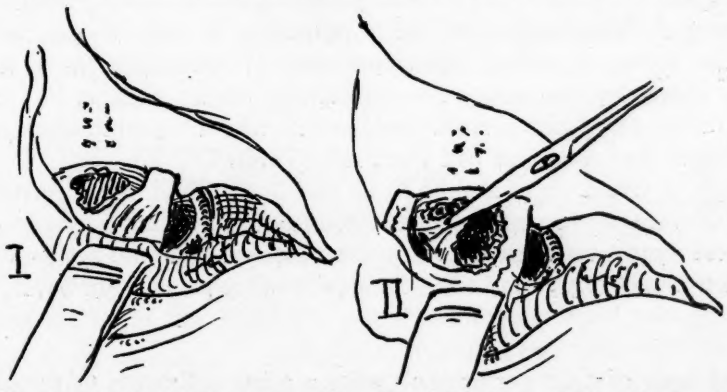


FIG. 615.—Operative sketch from a case with unilateral disturbance of vision showing: I, Marked compression of the right optic nerve with destruction of its medial portion by a subjacent mass of the tumour which protrudes through the bulging diaphragma; II, Emptied capsule being withdrawn. Tumour visible to right of nerve pushing carotid artery outward.

with complete temporal hemianopia and a visual acuity of 20/100 in the right eye, but no definite visual disturbance in the left eye. The radiograph showed, in addition to a large sella, that the right anterior clinoid process was largely absorbed. The mesial edge of the right optic nerve was extremely flattened and that part of it which had obviously been destroyed by compression was sacrificed in order to facilitate access to the lateral extension of the tumour, which could be seen protruding to the right of the nerve. The left optic nerve, on the other hand, was only very slightly displaced by the dome of the tumour and its function had not been affected.

X-ray evidence of an eroded or absent anterior clinoid as an indication of an expanding lesion on the side of the affected eye was observed in several other cases. Compression of one optic nerve and absence of the anterior clinoid are sometimes the only signs of other tumours in the same region, especially meningiomas on the inner part of the sphenoid ridge and, less commonly, aneurysms.

Approaching blindness in one eye, due to a large central scotoma, may be the only clinical evidence of a pituitary adenoma, as was true of three patients in this group; in two of them the sella was not enlarged. That a suprasellar adenoma may compress only one optic nerve, with the production of a unilateral central scotoma as its only manifestation, emphasizes the importance of exploring cases of unexplained monocular loss of vision, as well as the more common cases of obscure (clinically and radiologically) bitemporal hemianopia. Attention has already been drawn to the fact that if patients with a visual defect in only one eye are not operated upon before the eye becomes blind, the adenoma may produce no new manifestations until it has reached so advanced a stage as to be inoperable. This happened to several of the patients in Group 3 (e.g., *Case* 8).

SUMMARY OF GROUP 5.—Involvement of only one optic nerve, either by a lateral extension of the adenoma beneath the diaphragma, or by a nodule of tumour which has penetrated through the diaphragma, may cause as its only manifestation a unilateral field defect bearing no resemblance to the usual temporal hemianopia. The sella may be normal in size, but the corresponding anterior clinoid process is sometimes eroded. It is easily understood why, under these circumstances, better results follow the transfrontal operation, which gives direct access to a lesion wholly inaccessible by the transsphenoidal approach.

6. Bilateral Blindness.—Of the 7 examples, in only 2 was there a slight post-operative return of vision. The possibility of restoring sight to a blind eye, however, is shown by the results of operation in the 25 patients in Group 3 and also in 35 of the 165 patients from Group 1 in whom vision in one eye had been reduced to light perception or had been lost (*Tables IV, V*).

Recovery of vision up to 20/100 in an absolutely blind eye occurred in several patients in whom the eye was known to have been blind for periods of up to three months; and almost complete recovery was observed after the eye had been blind for only a few weeks (e.g., *Case* 18). In all the other patients, however, in most of whom the eye had been blind for a longer duration, and often for several years, there was no post-operative return of sight.

The presence of light perception makes a great difference to the chances and the degree of recovery. In the majority of these cases there was an improvement after operation, and in some of them it occurred even after vision had been reduced

to that level for at least one and possibly two years. The degree of recovery was usually quite considerable and worth while, and in some instances when the vision had been reduced to light perception for only a few weeks the restoration was complete (e.g., in *Cases* 2 and 10 after vision in one eye was known to have been reduced to light perception for at least seven weeks before operation).

It is believed, therefore, that visual recovery cannot be expected in an eye that is known to have been completely blind for six months or longer. But whether a surgeon should ever feel justified in sacrificing what may appear to be a useless optic nerve in order to obtain better access, particularly if the duration of absolute blindness is not accurately known, must depend upon the special circumstances in each case. Allowance must always be made for the possibility of a recurrence which is just as likely to affect vision in the good eye, so that the recovery of even a little vision in the poor eye may, at some future date, be of great service to the patient. The retention of light perception should in Dr. Cushing's opinion be sufficient reason for preserving the optic nerve.

7. Normal Vision.—It is exceptional for a chromophobe adenoma to be diagnosed or even suspected before it is sufficiently large to implicate the visual pathways. Such manifestations as are due to pituitary insufficiency (e.g., amenorrhœa, increase in weight) resulting from compression of the normal glandular tissue, are not likely to be regarded as serious, and their true significance is appreciated only in retrospect after the appearance of visual symptoms. Furthermore, symptoms of glandular dysfunction are quite common apart from the presence of a pituitary tumour, and even if X-ray examination did disclose an enlarged sella, operation would hardly be justified before vision is affected. In this series there were no cases of this kind in which the only manifestations were those of pituitary insufficiency.

There were, however, 4 unusual cases, all with normal vision, which have been put into a separate group because the operation findings showed that a chromophobe adenoma may, in rare instances, engulf the optic nerves without damaging them, and even produce a massive intracranial extension, the symptoms of which are the chief manifestations of the tumour. Acidophil adenomata not uncommonly spread around the arteries and even the nerves in this manner.

The operative sketch in the following case roughly shows the unusual condition disclosed by an adenoma of this kind. Pathologically, the case belongs to the subgroup of mixed adenomata (fugitive acromegaly).

Case 13.—M. J. B., aged 28 years, a clerk (P.B.B.H. Surg. No. 41294), was admitted on *June* 7, 1932. He complained chiefly of intermittent frontal headaches by which he had increasingly been victimized for six years. He had gained 40 lb. in weight about four years before admission; there had been considerable lassitude for two years, and he had been impotent for about nine months. He had received four X-ray treatments one month before admission without any improvement.

On examination his general appearance was suggestive of acromegaly, but there were no signs of recent activity. The visual acuity and fields were normal (*Fig.* 616), but the sella was considerably expanded (23 × 18 mm.).

On *June* 16, 1932, a right transfrontal exploration disclosed a large soft pituitary adenoma which enveloped and completely concealed the optic nerves (*Fig.* 617). They were brought into view only when the supradiaphragmatic mass of the adenoma had been carefully removed, after which the intrasellar portion of the tumour was radically excavated. Vision remained normal after operation. The headaches and lassitude gradually disappeared and normal sexual function returned.

When he reported for examination on *Nov.* 4, 1936, the visual acuity and fields were normal. He had enjoyed good health, had worked regularly, and was the father of a child 12 months of age. He had received no post-operative X-ray treatment.

He wrote on *June* 17, 1938, the sixth anniversary of his operation, to say that his excellent health continues and permits him to do considerable overtime work at his job.

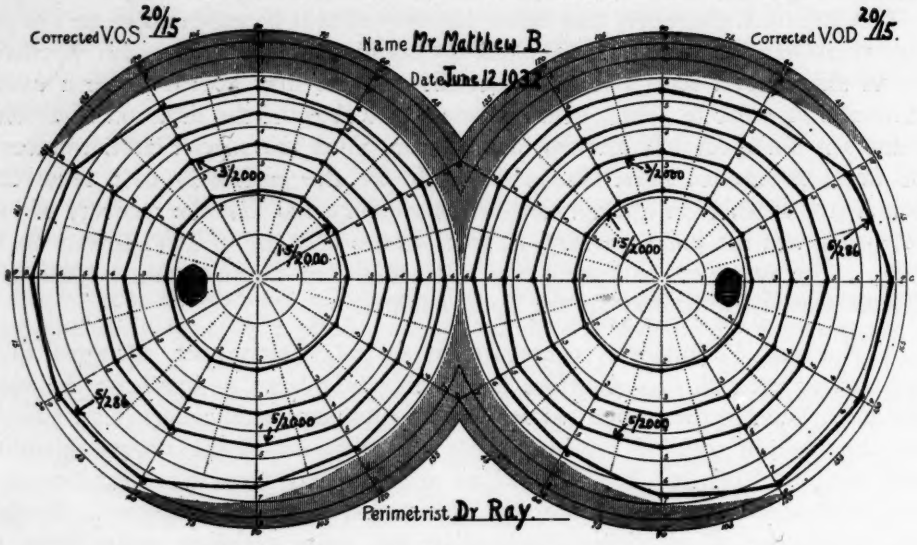


FIG. 616.—*Case* 13. Normal vision and fields before operation even though the optic nerves were surrounded by tumour, as shown in *Fig.* 617.

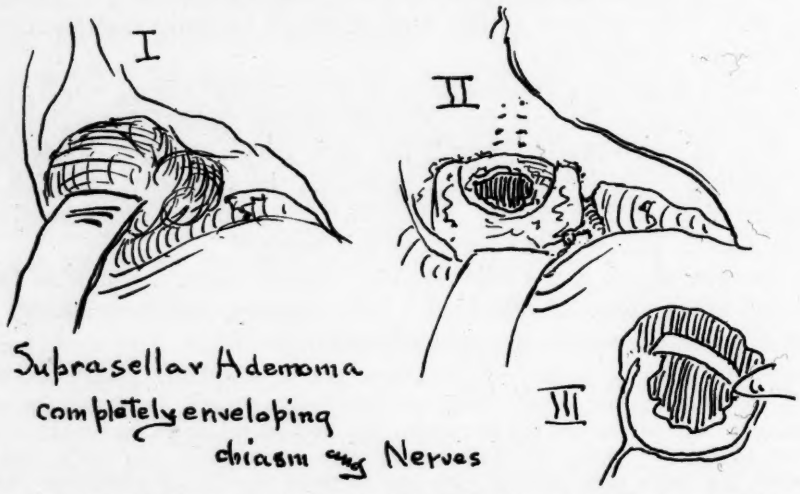


FIG. 617.—*Case* 13. Operator's sketches showing: I, Optic nerves completely concealed by suprasellar extension of adenoma without having caused any impairment of vision; II, Appearance after exposure of nerves; III, Estimated amount of tissue removed.

COMMENT.—Of chief interest in this case was the unusual appearance of the tumour when first seen during the exposure of the chiasmal region. The indications for operation were the severe headaches and ballooned sella.

The surgical indications in the other patients with normal vision were chiefly the effects of a large intracranial extension, namely, involvement of the oculomotor and

trigeminal nerves, bouts of severe headache and vomiting, mental changes, epilepsy, and X-ray evidence of a large sella, which may even be completely obliterated.

Chromophobe adenomata, therefore, may produce extensive destruction of the sella and basisphenoid, engulf the optic nerves, and even project upwards to form a large intracerebral mass, without producing any visual disturbance.

C. THE LATE RESULTS OF OPERATION

As shown in *Table VI*, only 3 of the 247 patients who survived operation have failed to report. All 3 were operated upon before 1920. The present status of the remaining 244 patients is known, though 2 of them who had reported regularly after operation for two and ten years respectively have failed to do so recently. The follow-up statistics at the 5-years' interval after operation are, therefore, complete for all except 4 of the 247 patients.

Table VI.—CHROMOPHOBE ADENOMATA: SUMMARY OF FOLLOW-UP OF THE 247 PATIENTS WHO WERE DISCHARGED FROM HOSPITAL

	No. of Cases	
Alive and well with no evidence of recurrence (from two to twenty-one years after operation)	97	
Alive and well (after further operation or X-ray treatment for recurrence of symptoms)	29	
Alive with recurrence of symptoms (untreated) ..	15	
	—	141
Dead from recurrence of tumour (including 9 patients in whom either the date or the cause of death is unknown)	79	
Dead from incidental causes without recurrence of symptoms	24	
	—	103
Untraced		3
Total ..		247

It is customary in reporting a follow-up study of any tumour series to give the survival rates, usually at intervals of five or ten years after operation. Such figures are often useful in evaluating different methods of treatment for malignant tumours, especially when both the local effects of the tumour and the danger to life (usually from metastases) become evident more or less concurrently. Pituitary tumours do not endanger life by the production of metastases, but the patients are usually incapacitated from the loss of eyesight alone long before there is any danger to life from the local effects of the growth on the brain. The statistics of the survival rates at 5, 10, 15, and 20 years after operation are, therefore, of little value in discussing the treatment of pituitary tumours; they are summarized in *Table VII*,

Table VII.—CHROMOPHOBE ADENOMATA: NUMBER OF PATIENTS KNOWN TO BE ALIVE AT INTERVALS AFTER OPERATION

INTERVAL AFTER OPERATION	MAXIMUM NUMBER OF PATIENTS	NUMBER OF PATIENTS KNOWN TO BE ALIVE	PERCENTAGE
5	247	184	74·5
10	154	78	50·7
15	68	25	36·7
20	42	10	23·8

without further comment except to add that approximately one in four of the patients was still alive at the 20-years' interval after operation. Since this indicates that many of the patients are now well past middle life, reference must be made to the age incidence of pituitary tumours and to the frequency of death from incidental causes in the older patients.

The *age incidence* of patients with chromophobe adenomata at the time of admission to hospital is shown in *Fig.* 618. The maximum incidence is during the age period 35–45, so that twenty years after operation many of the patients are in the neighbourhood of 60 years of age or over. There were only 3 patients under 18 years of age; the youngest, a girl of 10 years, and two of 14 years. Advancing age is not a contra-indication to operation, for among the 25 patients of 55 years or over (2 of them at the time were having secondary operations for recurrences),

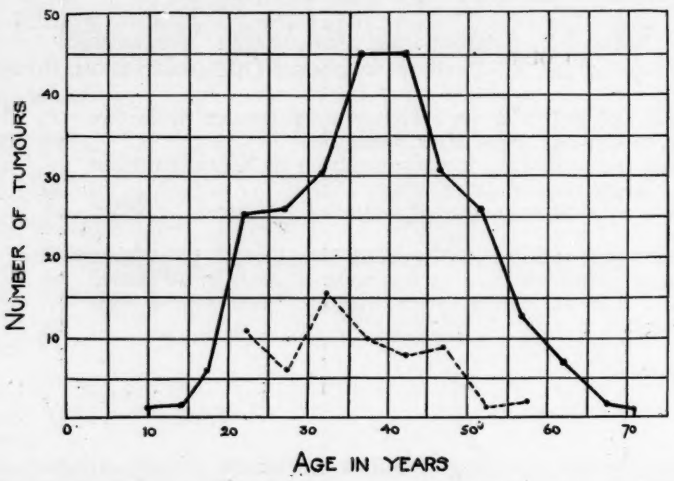


FIG. 618.—Graph showing the age distribution of patients on admission to hospital with the two principal types of pituitary adenomata: 260 chromophobe (solid line); 67 acidophil (interrupted line).

there was only 1 post-operative fatality; this occurred in a man of 71 years (cf. *Case* 27), the oldest case in the series, who succumbed to a post-operative extradural blood-clot. The operation risk is therefore no higher in elderly patients than for the series as a whole, and the early and late results are also equally good.

Of the 24 patients who are known to have died from some cause quite unrelated to the pituitary tumour, as was proved at post-mortem examination in most cases, 8 died of cardiovascular diseases and apoplexy after middle life, 3 of proved abdominal carcinoma, 3 of an acute abdominal emergency, while the remainder succumbed to a variety of causes.

The local effects of chromophobe adenomata are so important that the late results should be judged entirely by the duration of freedom from recurrence of symptoms. At the end of five years after operation there was no evidence of recurrence in approximately 50 per cent of all patients. This figure, however, represents the average results of different forms of treatment over a period of 20 years and not the results of present-day treatment; in view of the fact that there has been a progressive and remarkable improvement in the late results, the figures

for the cases earlier in the series after intervals of 10, 15, and 20 years are of little importance, and need not be given.

The treatment of pituitary tumours has changed considerably during the twenty years from 1913 to 1932, as regards both the type of operation and the use of X-ray treatment as an adjunct to operation. This change is shown in *Table VIII*, from which it is seen that there were three main periods, in each of which one particular form of treatment was used more or less routinely. They are: (1) 1913–19, transsphenoidal operations alone; (2) 1920–28, mostly transsphenoidal operations followed by X-ray treatment; and (3), 1929–32, transfrontal operations, with or without X-ray treatment. The late results show a striking improvement in each successive period. During the 1913–19 period, only 20 per cent (10 out of 49 patients) did not have a recurrence of symptoms at the end of five years; for the years 1924–6 the proportion had increased to 55 per cent (33 out of 60 patients); and for the years 1929–32 as many as 71 per cent (45 out of 63 patients) were free from any sign of recurrence five years after operation.

Table VIII.—CHROMOPHOBE ADENOMATA: THE NUMBER OF PATIENTS WHO HAD PRIMARY OPERATIONS AND ADDITIONAL POST-OPERATIVE X-RAY OR RADIUM TREATMENT EACH YEAR

THE YEAR 19..	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Transsphenoidal operation	7	7	8	17	6	1	8	11	7	9	7	16	13	24	17	7	1	1	—	—
Transfrontal operation	—	—	1	—	1	—	—	—	2	3	8	6	—	2	3	3	12	23	18	11
X-ray treatment	—	—	—	—	—	—	—	5	1	1	13	16	11	10	4	5	3	9	8	2
Radium treatment	—	—	—	—	1	—	—	—	3	5	—	—	—	—	—	—	—	—	—	—

It is thus quite clear that the late results were greatly influenced by the type of operation and by the addition of post-operative X-ray treatment. This indication was followed up by arranging the cases into four groups, i.e., for the transfrontal and the transsphenoidal operations, each with and without X-ray treatment. Only those patients who never had X-ray treatment or who are known to have had what is regarded as adequate treatment (one or more courses of four treatments each), either at the Brigham Hospital or in other clinics with suitable facilities for giving such treatment, have been included, i.e., a total of 187 out of a possible 247 patients. Those who had treatment of unknown dosage elsewhere, who died of some cause unrelated to the tumour, or who ceased reporting before the end of five years, have not been included. On this basis, the number of patients who have not had any recurrence of symptoms up to the present time are shown, according to the length of interval after operation, in *Table IX*; and, similarly, *Table X* shows the number of patients who developed recurrence of symptoms and the time at which the symptoms first appeared after operation.

In comparing these two tables, attention may be drawn to:—

a. The 33 patients who remained free from symptoms for more than 10 years after a transsphenoidal operation, 24 of whom had X-ray treatment in addition; and more particularly the group of 10 patients who remained

Table IX.—CHROMOPHOBE ADENOMATA: THE DURATION OF IMPROVEMENT MAINTAINED TO DATE

YEARS AFTER OPERATION		-1	1+	2+	3+	4+	5+	6+	7+	8+	9+	10+	11+	12+	13+	14+	15+	16+	17+	18+	19+	20+	21	TOTAL CASES
NO X-RAY TREATMENT	Sphenoidal operation	—	—	—	—	—	1	1	1	1	5	1	—	1	—	—	—	2	—	—	1	3	1	18
	Frontal operation	—	—	—	—	—	8	6	4	3	—	—	—	—	—	—	—	—	—	—	—	—	—	21
WITH X-RAY TREATMENT	Sphenoidal operation	—	—	—	—	—	—	1	2	2	3	1	8	6	4	2	—	3	—	—	—	—	—	32
	Frontal operation	—	—	—	—	—	13	3	3	1	—	—	—	3	3	1	—	—	—	—	—	—	—	27
																						Total		98

Table X.—CHROMOPHOBE ADENOMATA: THE INTERVALS BEFORE THE APPEARANCE OF RECURRENT SYMPTOMS

YEARS AFTER OPERATION		-1	1+	2+	3+	4+	5+	6+	7+	8+	9+	10+	11+	12+	13+	14+	15+	16+	17+	18+	19+	20+	21	TOTAL CASES
NO X-RAY TREATMENT	Sphenoidal operation	10	15	11	7	2	1	2	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	49
	Frontal operation	3	7	3	3	1	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	19
WITH X-RAY TREATMENT	Sphenoidal operation	3	4	3	2	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	17
	Frontal operation	2	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4
																						Total		89

well for sixteen to twenty-one years after a seemingly incomplete removal of the adenoma from below, 7 of whom received no X-ray treatment. It may be added that 5 other patients also remain well after total periods of from sixteen to twenty-two years, following the successful treatment of recurrences in the interval.

b. The transsphenoidal operations for the year 1920 were especially gratifying, for of the 11 patients, 5 are still free from symptoms sixteen years later, and in another instance (*Case* 16) a recurrence was successfully treated with complete relief to date.

c. The symptoms of recurrence appeared within five years in about 95 per cent of the recurrent cases, and within three years in 70 per cent. No recurrence became manifest later than eight years after operation. This is further indicated by what happened to 14 of the 19 patients (cf. *Table VIII*) who had transfrontal operations during the years 1921–24, i.e., more than twelve years ago: 7 patients, all of whom had X-ray treatment, have maintained their improvement to date; the other 7 had recurrences, some of them after receiving post-operative X-ray treatment, and the symptoms appeared within three years in all but one patient, who had a six-year symptom-free interval.

The figures for the total number of cases with recurrences and without recurrences cannot strictly be compared as they stand in *Tables IX* and *X*, because the maximum post-operative interval for the majority of the transfrontal cases is less than ten years, whereas for the majority of the transsphenoidal cases it is longer than ten years. As nearly all recurrences seem to become manifest within five years, a fairly good idea of the relative values of the two operations and of post-operative X-ray treatment may be obtained by comparing the results at the end of

Table XI.—CHROMOPHOBE ADENOMATA: THE PERCENTAGE OF PATIENTS WITHOUT RECURRENCE AT 5 YEARS, ACCORDING TO THE TYPE OF OPERATION AND X-RAY TREATMENT

TREATMENT	NUMBER OF CASES WITHOUT RECURRENCE AT 5 YEARS	PERCENTAGE
Transsphenoidal operation only	22 out of 67	32·8
Transfrontal operation only	23 out of 40	57·5
Transsphenoidal operation + X ray	32 out of 49	65·3
Transfrontal operation + X ray	27 out of 31	87·1

five years. This is easily done by transferring the 6 recurrences after five years from *Table X* to *Table IX*. The figures thus obtained are shown in the form of percentages in *Table XI*, and are represented diagrammatically in *Fig.* 619. This demonstrates quite clearly the superiority of the transfrontal operation as regards the late results, and the highly beneficial effect to be derived from additional post-operative X-ray treatment.

This collection of 187 cases, well controlled, but otherwise not specially selected, can be regarded as a good series from which to evaluate the different forms of

treatment after a reasonable interval, because the vast majority of the operations were performed by one surgeon. The conclusions to be drawn may be summarized as follows :—

1. The improved late results after the transfrontal operation as compared with the transsphenoidal operation are most likely due to the more thorough excavation of the adenoma that is usually possible when looking directly into the sella from above.

2. Prophylactic X-ray treatment given within a month or two of operation delays, and probably in many cases completely inhibits, any recurrence of tumour growth.

3. There appears to be great variation in the rate of growth of chromophobe adenomata and in their behaviour after operation. They may be divided roughly into the following three groups :—

a. Adenomata whose growth is slowed or spontaneously arrested after a partial excavation, as shown by the seven patients who have survived without symptomatic recurrence for more than sixteen years after a transsphenoidal operation, without additional X-ray treatment. In a few instances there was a recurrence of visual failure which progressed so far and then stopped spontaneously and remained stationary for a long period; and in others a recurrence progressed until blindness supervened, after which the patients remained in good health for many years. It seems reasonable to assume that a spontaneous cessation of growth of the adenoma had occurred in these cases.

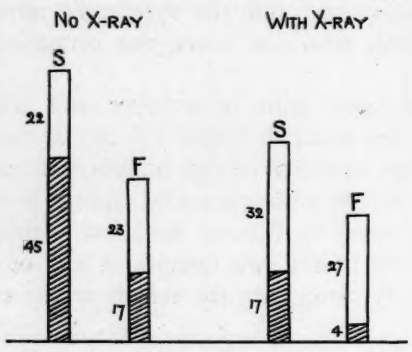


FIG. 619.—Diagram showing the influence of the type of operation and of post-operative irradiation on the recurrence rate at the end of five years. The clear area represents cases without recurrence and the shaded area the cases with recurrence. The numbers of transsphenoidal (S) and transfrontal (F) operations are shown.

b. Adenomata which produce signs of recurrence a few years after the usual incomplete removal, but which appear to be very definitely affected by post-operative X-ray treatment, so that the recurrence is greatly delayed or actually prevented; this is the largest group.

c. A small group of adenomata whose rapid growth is apparently not affected by operation or by X-ray treatment, for even what may be regarded as the ideal treatment, i.e., transfrontal operation plus X-ray treatment, is quickly followed by recurrence of symptoms.

It is, of course, important to take into consideration these differences in the spontaneous behaviour of chromophobe adenomata when the results of X-ray treatment, or of operation, are reported for small groups of cases after a brief period of time.

The tumours of the cases in these well-defined groups have not been re-examined histologically, so that it is not possible to say if there is any correlation between their structure and the post-operative course, including their sensitivity to X-ray therapy, which might serve as a guide to prognosis.

D. X-RAY TREATMENT

It has just been shown that there is a definite improvement in the late results of operation when it is followed by X-ray treatment. The question of the value of X-ray treatment for chromophobe adenomata will now be considered, from the material in this series, under three headings: (1) X-ray treatment alone; (2) The effect of post-operative X-ray treatment on the operative results; (3) The treatment of recurrences by X rays alone.

Only those patients who have had what is regarded as adequate treatment, given either at the Brigham Hospital or in other clinics known to have facilities for such treatment, are considered. A small number of patients who received only a single exposure of X rays, usually before operation, are not included.

I am indebted to Dr. M. C. Sosman[23] for the following description of the technique of X-ray treatment for pituitary adenomata employed at the Brigham Hospital during the period included in this series.

a. Before 1928 (cf. Dott and Bailey, p. 361).[14]—Three portals of entry 3½ in. square in each temporal region and occasionally in the frontal region were used. The treatments consisted of a maximum skin dose at each sitting, and were composed of approximately the following factors:—

Spark gap, 9 to 10 in.
Voltage, 80,000 to 100,000 volts, r.m.s.
Distance (target to skin), 12 in.
Filter, 0·25 mm. copper and one thickness of sole leather.
Time, 30 min.
Amperage, 5 ma.

This usually caused an epilation of the areas treated, but rarely an erythema. Single treatments were usually given on successive days. Treatment through one area was not repeated at an interval of less than three weeks.

b. After 1928.—The factors used were 180 k.v., 50 cm. skin target distance, ½ mm. copper and 1 mm. aluminium filter with daily doses of 350 r, giving two treatments to each temporal region.[21]

1. Before Operation.—Only a small group of 10 patients had a trial period of X-ray treatment which had been completed at least one month before operation. In 7 of the 10 cases it produced no improvement, in 2 there was slight improvement, and in 1 a marked improvement (cf. *Case* 14, below). Subsequent transsphenoidal or transfrontal operations were followed in all except two of them by successful recovery of vision. The improvement after operation has been maintained for from five to twelve years to date, usually without further radiation, save for one patient who had a recurrence of symptoms after four years. It seems likely, therefore, from this small group of cases, that X-ray treatment alone does not give such good early results as operation.

The story may now be given of the patient in whom repeated X-ray treatments, although followed by temporary, and at first marked, improvement, had probably eliminated the chances of visual recovery after operation, which eventually became necessary.

Case 14.—W. D., a physician, aged 38 years (P.B.B.H. Surg. No. 39152), was admitted on *July* 5, 1931, with the complaint of recurring failure of vision.

In *October*, 1928, he first observed a dimness in the upper temporal quadrant of the left eye; this progressed, and examination in *January*, 1929, revealed a complete temporal

hemianopia with greatly reduced central vision in the left eye, an incomplete upper temporal defect with slightly impaired central vision in the right eye, and an enlarged sella. He had a course of X-ray treatment in another clinic in *June*, 1929, after which vision returned to normal in both eyes.

After a time there was a slight regression in vision which was again restored to normal by a second course of X-ray treatment in *October*, 1929. Vision then remained stationary

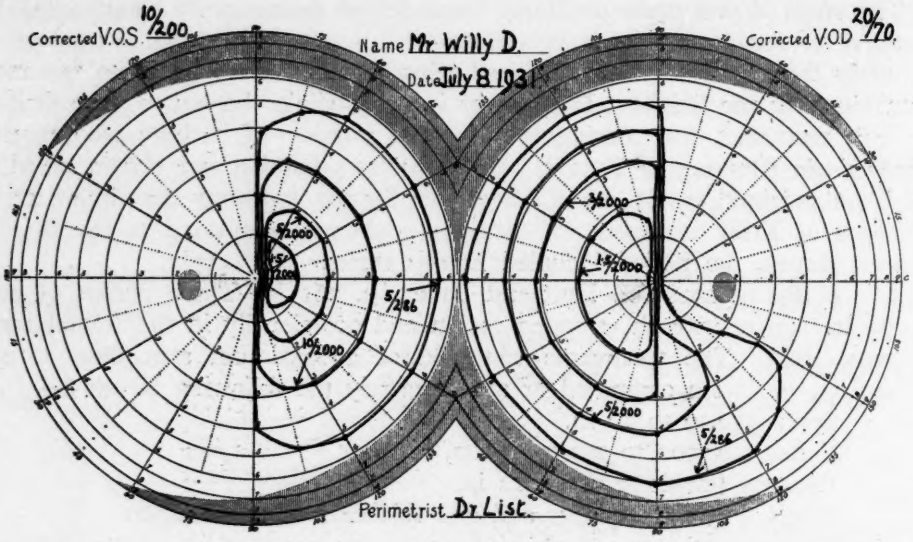


FIG. 620.—*Case* 14. Visual fields before operation on a patient who during the previous two years had received three courses of X-ray treatment, each followed by temporary improvement.

until *September*, 1930, when it again became affected, and examination in *January*, 1931, showed, as before, a complete temporal hemianopia in the left eye and an upper temporal quadrantal defect in the right eye. A third course of X-ray treatment at the same clinic in *April*, 1931, was followed this time by only very slight improvement in vision which lasted for barely two months, and radiographs taken at that time showed a further considerable enlargement of the sella.

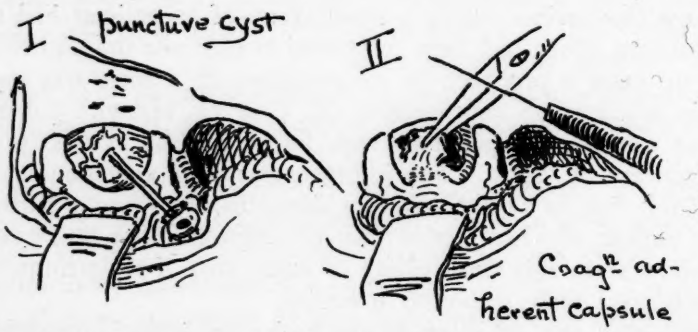


FIG. 621.—*Case* 14. Operative sketches to show: I, Preliminary aspiration of the tumour through the bulging and intact diaphragma; II, Adhesions between tumour capsule and chiasma ascribed to the intensive pre-operative X-ray therapy.

On his hospital admission the patient showed almost complete bitemporal hemianopia (*Fig.* 620) with V.O.S. 10/200 and V.O.D. 20/70, considerable optic atrophy, especially in the left eye, and a large sella (30 × 17 mm.).

On *July* 11, 1931, a right transfrontal exploration was made. The adenoma was easily emptied of its soft and partly cystic contents by suction. It was found, however, that the

tumour had perforated the diaphragma and become strongly adherent to the chiasma (*Fig.* 621); such adhesions between tumour and chiasma had never before been encountered. The attempt to separate the tumour had to be abandoned for fear of causing further damage to vision.

There was no change in the visual acuity or fields after operation. He had no more X-ray treatment. When he was last heard from five years later, in the summer of 1936, there had been no further recurrence of symptoms, and he was in excellent health and was actively engaged in his professional work.

COMMENT.—This was the only instance in the entire series of more than a hundred transfrontal operations in which the tumour had become adherent to the chiasma. In several cases, on the other hand, without pre-operative X-ray treatment the adenoma had surrounded the optic nerves without becoming adherent, and its removal was followed by recovery of vision. There is a striking contrast

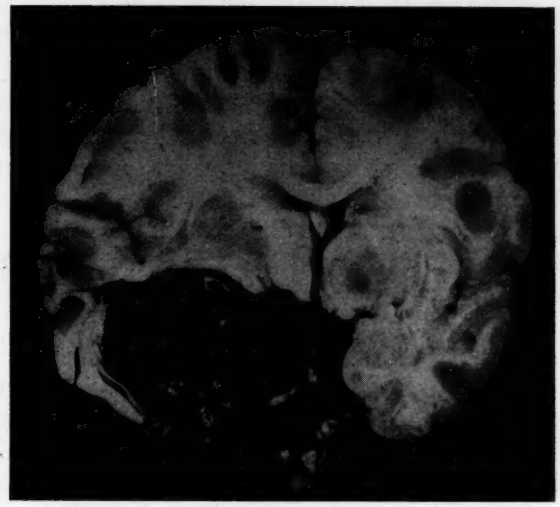


FIG. 622.—A large unsuspected extension of a chromophobe adenoma into the right temporal lobe. The patient had had intensive X-ray treatments with temporary improvement during the previous eighteen months. Note the absence of deformity of the third ventricle.

between the only temporary improvement after successive X-ray treatments during the two years before operation, and the complete freedom from further trouble for five years after operation without additional irradiation.

Not only may the adenoma become adherent to the chiasma during a trial period of X-ray treatment, but it may expand intracranially even though each series of treatments was followed by temporary improvement in vision. *Fig.* 622 shows a large unsuspected extension of an adenoma into the temporal lobe in a man of 37 years (P.B.B.H. Surg. No. 32647) who had had intensive X-ray treatment during the previous eighteen months (in three series between September, 1928, and August, 1929). Each successive series of treatments was followed by a temporary but progressively less marked improvement. Not until his general health and powers of concentration were affected did he consent to operation, which had a fatal outcome. As Dr. Cushing has related elsewhere (1932, p. 76[10]), the large temporal extension was first disclosed at autopsy.

This patient had shown periodic fluctuations in the type of visual defects,

sometimes with a tendency to bitemporal, and at others to homonymous, hemianopia, but always difficult to chart. At the time of operation vision was reduced to 20/200 in both eyes owing to the presence of large central scotomata without any hemianopia in the peripheral fields, so that there was no indication of the temporal extension. The illustration shows how a protrusion can slip out under the chiasma and expand into the temporal lobe without producing much displacement of the third ventricle or optic tract—a point already referred to in discussing the mechanism of homonymous hemianopia.

There is no doubt that such prolonged delay while preliminary X-ray treatment is being tried often adds to the hazards of operation as in this instance; it is much better to reverse the process and give X-ray treatment after operation.

2. Post-operative.—Many of the patients received prophylactic X-ray treatment after operation (cf. *Table VIII*). This usually consisted of one or two series of three or four treatments each, the first being given within a few weeks after operation and then perhaps a second series from three to six weeks later, often after the patient's discharge from hospital. Occasionally, treatment was continued and several courses were given at three- or six-monthly intervals during the next year or two. Many of the patients had already shown considerable improvement in vision before the post-operative irradiation was begun, so that it has not been possible to determine the relative effects of the operation and of the X-ray treatment in restoring vision in individual cases; there was no difference on a statistical basis in the early results of those who did and did not have post-operative X-ray treatment.

Although the effects of X-ray treatment are thus indeterminate and are probably negligible as regards the early results after the sella has been emptied, it has been possible to show that it has a very beneficial effect on the late results, as described in the previous section. The analysis of 187 patients, who either had no X-ray treatment, or had one or more series of treatments (it appears to make little difference whether given after or before operation), has shown that a considerably smaller proportion of the patients who had X-ray treatment developed signs of recurrence by the end of five years (cf. *Fig.* 619). This clearly indicates that X-ray treatment delays, and in many cases probably prevents, the recurrence of symptoms after operation.

3. For Recurrences.—In 14 patients the symptoms of recurrence which appeared from one to six years after operation were treated by X rays alone. The results were variable. In 4 cases the vision which had been lost became gradually restored, and in all instances the improvement has been maintained for a period of from seven to twelve years (cf. *Cases* 16 and 17, below); none had received X-ray treatment previously. In 6 cases the visual decline was arrested and vision has since remained stationary, usually for a period of many years (e.g., *Cases* 3 and 15). In the remaining 4 cases X-ray treatment had no effect on the recurrent symptoms, which continued to progress; 2 of the patients had already received post-operative irradiation.

The three cases in which the most striking results were obtained will now be briefly recorded. In the following case a definite recurrence of visual failure two years after operation was permanently arrested by X-ray treatment for sixteen and a half years to date.

Case 15.—E. C., aged 46 years, a housewife (P.B.B.H. Surg. No. 8396), was admitted on *March* 20, 1918. There had been amenorrhœa for seven years, occasional slight headache and failing vision, especially in the left eye, for six years, and she had gained 40 lb. in weight. The left eye had been almost blind for three years.

On examination, there was considerable pallor of the optic disks, especially in the left eye, bitemporal hemianopia (*Fig.* 623), V.O.D. 20/100 and only light perception in the left eye. The sella was large.

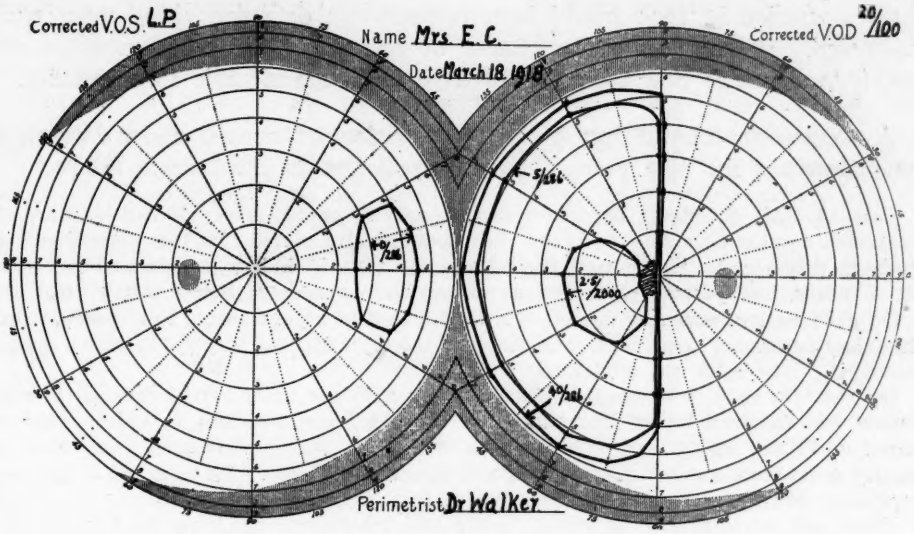


FIG. 623.—*Case* 15. Fields of vision on admission.

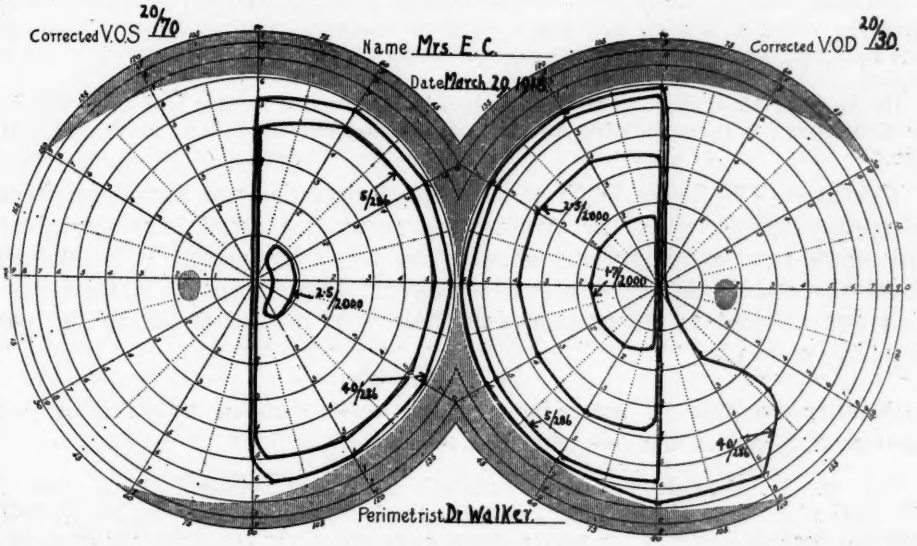


FIG. 624.—*Case* 15. To show the striking improvement eight days after the transsphenoidal operation.

On *March* 21, 1918, a fairly radical removal of a soft, solid adenoma was made by the transsphenoidal route. This was followed by prompt improvement in vision to 20/70 in the left eye and 20/30 in the right eye (*Fig.* 624). No X-ray treatment was given.

She remained well for two years, but in *February*, 1920, there was a recurrence of the headaches with so marked a loss of vision that by *April*, 1920, examination showed complete

bitemporal hemianopia, V.O.S. 20/200 and V.O.D. 20/100. Between *May* and *July*, 1920, she was given two series of four X-ray treatments, since when her vision has remained unchanged. She has enjoyed good general health and been free from headaches.

On request she visited New Haven on *Nov.* 13, 1936. Despite her advancing years and impaired vision she was well able to conduct her household affairs.

COMMENT.—This recurrence was treated by radiation at a time when transfrontal explorations were not often made. Whether or not a secondary (transfrontal) operation in 1920 would have restored the defective vision must remain unanswered. Judging from the results of operations for recurrences in other cases, it is probable that there would have been considerable improvement.

A somewhat delayed but gradual restoration of normal vision, which has been maintained for nine years, followed irradiation in the case to follow.

Case 16.—M. E. McC., aged 29 years, a railway engine-driver (P.B.B.H. Surg. No. 13635), was admitted on *Dec.* 6, 1920. For about twelve months he had noticed difficulty in judging distance (he had passed the railway eye tests in March, 1919), and the impairment of vision had become more serious during the six months before admission.

On examination, acuity in the left eye was reduced to 20/200 owing to a central scotoma without any peripheral hemianopia, and vision in the right eye was only 7/200 with a temporal hemianopia. The sella was moderately enlarged.

On *Dec.* 18, 1920, a transsphenoidal operation with the usual partial removal of a solid adenoma was followed by an immediate and continued improvement in vision which was restored to V.O.S. 20/15 and V.O.D. 20/20 by *August*, 1921; the visual fields were fully expanded apart from a slight inferior temporal defect in each eye. He returned to his former occupation. No X-ray treatment was given at that time.

There was a recurrence of visual failure and bitemporal headache in *January*, 1925, i.e., four years after operation, and when he was examined by the late Dr. C. E. Locke at the Cleveland Clinic in *March*, 1925, the visual fields showed a temporal paracentral scotoma with 20/50 vision in the left eye, and a complete temporal hemianopia with 20/40 vision in the right eye. X-ray treatment was given immediately and was followed by rapid recovery of vision.

He wrote in *May*, 1937, to say that he had had no further trouble and had worked full time since 1925; a recent ophthalmological examination showed V.O.S. 20/20 and V.O.D. 20/30.*

COMMENT.—While the result of the primary operation was highly satisfactory, a secondary operation for the symptomatic recurrence could not have given a better result than was apparently obtained by X-ray treatment. It is interesting to note the association between central scotoma and inferior quadrantal defects which was referred to when discussing these field defects earlier in the paper (cf. p. 850 et seq.).

Another example of somewhat delayed restoration of vision after X-ray treatment occurred in the following case:—

Case 17.—M. M., aged 35 years, a housewife and factory worker (P.B.B.H. Surg. No. 30206), was admitted on *Nov.* 30, 1927, with the complaints of impaired vision and headaches. There had been amenorrhœa for twelve years, occasional slight headaches for seven years, progressive blurring of vision for two and a half years with recent inability to read, and subjective bitemporal hemianopia. She had gained 30 lb. in weight, and for six months she had noticed occasional diplopia when looking at distant objects.

On examination, there was complete bitemporal hemianopia with 20/70 vision in each eye, slight pallor of the optic disks, and a moderately enlarged sella.

* He reported at New Haven on *Aug.* 22, 1938. His health was very good. V.O.S. 20/15 V.O.D. 20/25.

On *Dec.* 13, 1927, a radical extirpation by suction of a relatively soft adenoma was carried out by the transsphenoidal route. This was followed by a gradual improvement in vision during the next five months to V.O.S. 20/30 and V.O.D. 20/50, with return of vision in the lower temporal quadrants. There were no further headaches, and she was able to resume her occupation. No X-ray treatment was given at that time.

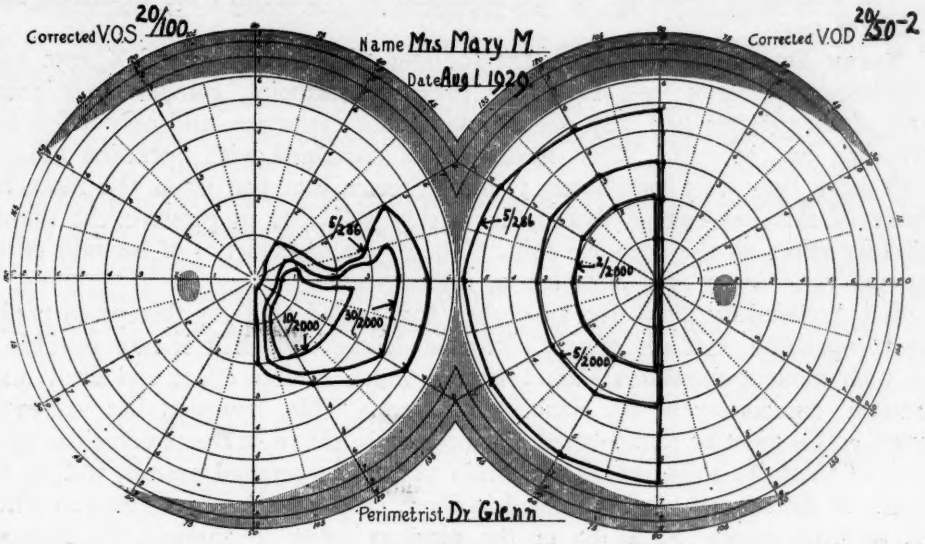


FIG. 625.—*Case* 17. Fields of vision on re-admission for symptomatic recurrence prior to X-ray treatment.

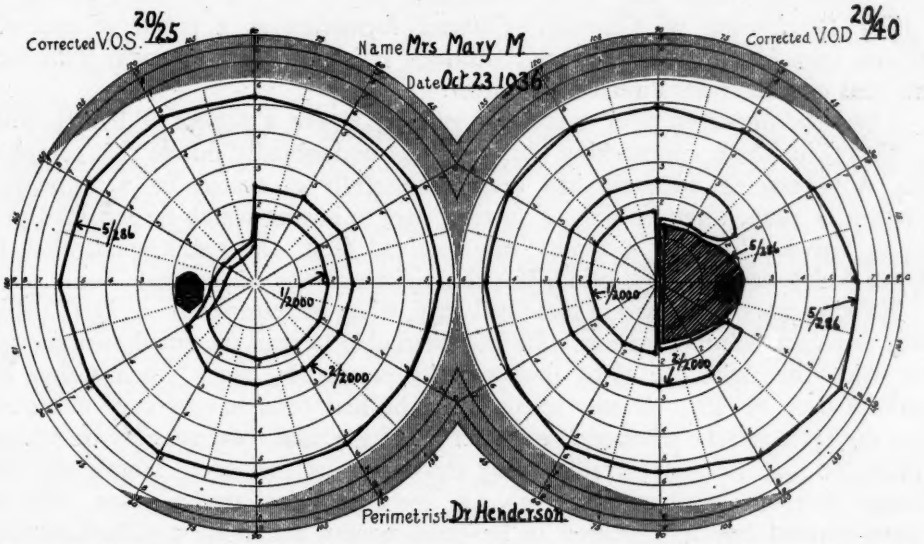


FIG. 626.—*Case* 17. To show present greatly improved visual status maintained for seven years since X-ray treatment.

She was re-admitted in *July*, 1929, having noticed during the previous four weeks some deterioration of vision, especially in the left eye (*Fig.* 625), together with headaches and diplopia for distant objects. X-ray examination showed a definite increase in the size of the sella. She had a series of four treatments in *September*, 1929. Although there was no immediate change, the headaches and diplopia disappeared and vision improved slowly during the next year.

When on request she reported to me at New Haven on *Oct.* 23, 1936, she could read the smallest print without fatigue and was leading a normal life. There had been no diplopia since the X-ray treatment, and she was subjectively aware of the bitemporal return of vision (*Fig.* 626).*

The results of operation in the treatment of recurrences are described later (p. 882 et seq.).

X-ray Dosage.—It is important to note that the dosage of X rays used throughout this series was, from our present standpoint, comparatively small. Many of the patients had only one course of four exposures, and only a few had more than two courses. When irradiation is combined with operation the late results have been very satisfactory; and it seems that one or at the most two courses of this low-voltage therapy is usually sufficient to produce the desired inhibitory effect on the adenoma cells. There was no evidence of harmful effects following this dosage even after ten or fifteen years.

It is believed by those who advocate a trial period of X-ray therapy in preference to operation, that the greatly increased dosage[21] which it is now possible to give with modern apparatus should have a much greater effect and even make operation unnecessary in the majority of cases. This, however, has yet to be proved, and it must be remembered that nothing is known of the possible damaging effects of intensive radiation on the brain tissue, the cerebral vessels, and on the remains of the normal pituitary gland in those cases with small tumours in which it is so often used. Radiation of the pituitary body in animals, for instance, retards growth, and it is possible that the intensive radiation which is used in certain types of glioma may have deleterious effects on the pituitary gland.

The Development of Cataract.—Cataract formation as a result of excessive radiation may be referred to briefly, although it is not likely to occur with well-controlled and carefully directed treatment.

I had the opportunity of examining at New Haven a patient (P.B.B.H. Surg. No. 18283) in whom approaching blindness was undoubtedly due to this complication. A suprasellar adenoma had been successfully excavated by a transfrontal operation in 1923, when he was 14 years of age, following which he regained good reading vision. In 1927 a report was received from another hospital that the left eye had become almost blind, but the right eye was unchanged.

Nothing more was heard of him until 1936, when he returned to see Dr. Cushing owing to recent failure of vision. He had been able to read the smallest newspaper print with the right eye until four months previously, since when vision had deteriorated to 20/200. It was learned that he had been having very infrequent minor epileptic attacks since one year after operation, and that, possibly on account of these, he had had innumerable X-ray treatments, at first every month and then at longer intervals, until one year ago, i.e., for a period of twelve years. He was in good general health, appeared to be quite normal mentally, and had not had headaches. There were large dense cataracts in both eyes—only the extreme periphery of the fundi could be seen.

This case illustrates very well the importance of maintaining contact with patients, not only to watch for any recurrence of the former trouble, but to prevent excessive or unsuitable after-treatment. There can be little doubt that the development of cataracts in this young man was due to excessive radiation.

* She reported again at New Haven on *Oct.* 15, 1938. Vision was unchanged and she was in good health.

It happened that two other patients who later developed cataracts had also received unusually prolonged X-ray therapy, but, as one was aged 59 years (cf. *Case* 28, p. 897) and the other 65 years, the appearance of the cataracts cannot be so definitely ascribed to the X-ray treatment.

Radium.—The effect of implanting radium into the lower part of the tumour by the transsphenoidal route, either during the operation or within the next few weeks, was tried as an adjunct to partial removal of the tumour in 9 patients (cf. *Table VIII*). It was used in 3 other patients, also during the years 1921–2, for the treatment of recurrences which had appeared several years after a previous transsphenoidal operation; in these instances the radium was applied to the roof of the nasopharynx just outside the sphenoidal sinus, without exposing the tumour. It was never implanted intracranially.

The results of those early experiences with radium were disappointing, and it was given up chiefly owing to the danger of meningitis which is apt to occur as a result of tissue necrosis between the nasopharynx and the intracranial spaces. Of the 12 patients treated, 4 died from meningitis after intervals of 3 weeks, 10 weeks, 15 months, and $4\frac{1}{2}$ years respectively (cf. p. 824). There were similarly long intervals before the onset of meningitis in two other cases, following the treatment of recurrences by radium implantations in other clinics; the intervals were 11 months (*Case* 20) and 18 months.

The group of patients who survived the risk of meningitis is too small to allow of any deductions as to the value of radium implantation. In some, symptoms of recurrence appeared after a few years, while others remained well for many years. The various results are illustrated in case reports (e.g., *Cases* 2, 19, and 20). In another patient (P.B.B.H. Surg. No. 10783) a recurrence of visual failure two and a half years after operation was arrested by radium and has remained stationary for eighteen years.

Cases with Delayed Improvement.—Brief reference must be made to several interesting cases in which the improvement in vision after operation and X-ray treatment was greatly delayed. Cairns alluded to this in reference to one of his patients (*Case* 9, p. 449)[3] who eventually showed a remarkable recovery of vision which, however, did not begin until six months after operation and continued during the next three years. The improvement (from 3/200 to 20/30) which Cairns observed in October, 1935, is still being maintained according to a recent report in October, 1937.

The following case is equally remarkable.

Case 18.—F. J. McK., aged 22 years, a typesetter (P.B.B.H. Surg. No. 22285), was admitted on *Oct.* 2, 1924. He had experienced slight headaches about fifteen months previously, and for twelve months there had been a marked blurring of vision; everything appeared as if it was seen through a thick fog. During the last six months he had been unable to read and had had to stop work.

On admission, he could just see to get about, and recognized people with difficulty. The left eye was blind (two months previously there was a large temporal paracentral scotoma and V.O.S. 3/200); V.O.D. 5/200 with temporal hemianopia (*Fig.* 627). There was only slight pallor of the optic disks. The sella was normal in size (8 × 10 mm.), although the posterior clinoids were atrophic.

On *Oct.* 7, 1924, a right transfrontal exploration was made. At the first inspection the optic nerves and chiasma were not displaced and appeared to be quite normal. There were cyst-like collections of fluid in arachnoid spaces in front of and to the right of the chiasma; these spaces were opened and the fluid evacuated. Further inspection then

revealed a nodular, soft tumour which lay underneath the chiasma and was protruding slightly forwards between the optic nerves (*Fig.* 628). The tumour was cleaned out in the usual manner.

There was no definite improvement in vision before he went home. He had several courses of X-ray treatment during the next six months. There was a steady improvement

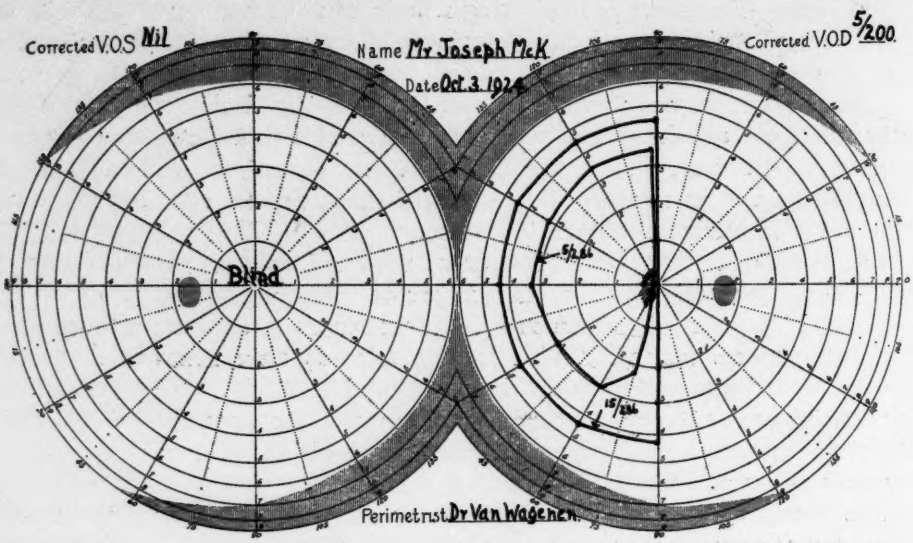


FIG. 627.—*Case* 18. Visual fields prior to operation, after which there was no immediate change.

during the first two years after operation; the visual fields taken on *Dec.* 18, 1925, showed that the hemianopia had become homonymous in type (*Fig.* 629). A temporary relapse in 1928, with bitemporal hemianopia, gradually disappeared after further X-ray treatment, and when he reported at the Brigham Hospital in *November*, 1936, examination revealed widely expanded fields, V.O.S. 20/25 and V.O.D. 20/50. X-ray examination showed that there had been no change in the size of the sella (8 × 10 mm.) during the intervening twelve years, and that it was normal in appearance. His general health was excellent, and for several years he had been doing full-time night work as a linotype operator on the staff of a Boston newspaper.

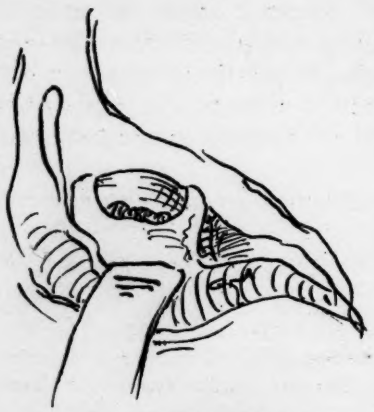


FIG. 628.—*Case* 18. Sketch showing small nodules of a suprasellar retrochiasmal adenoma just visible beneath the margin of a normal-appearing chiasma.

COMMENT.—It is remarkable that a man nearly blind before operation, without any immediate post-operative improvement, should gradually recover his sight during the next two years, to a point enabling him to resume an occupation requiring exceptionally good vision. This improvement was, no doubt, due in considerable part to the X-ray treatment. There was a similar slow recovery of sight over periods of from two to four years after operation in several other cases. Other interesting points in this case are: (*a*) The tumour was a suprasellar one; (*b*) The operative sketch shows how little evidence there may be of an adenoma and the importance of a good exposure of the chiasma; and (*c*) The change in the type of hemianopia from bitemporal to homonymous and back again.

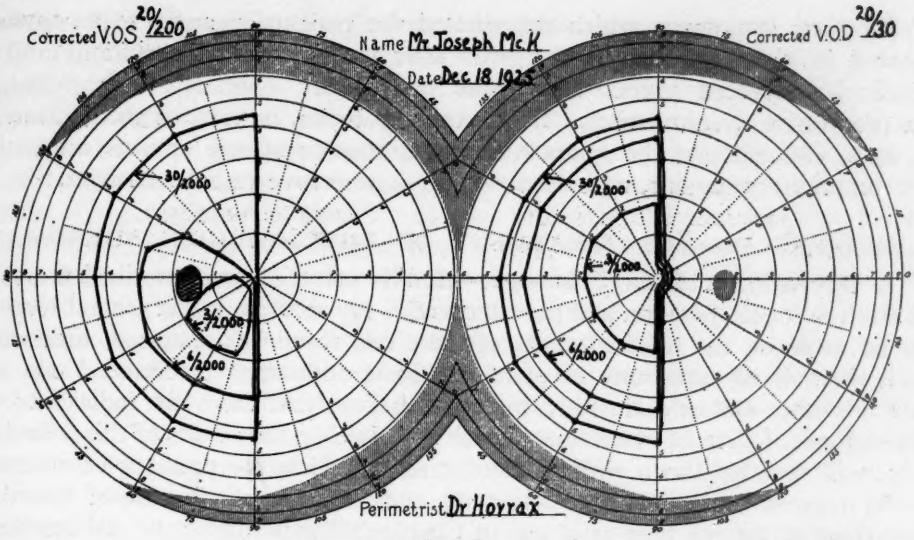


FIG. 629.—*Case* 18. Visual fields fourteen months after operation and X-ray therapy, showing homonymous hemianopia with improvement in acuity of vision.

Recalcification of the Sella.—It was noted in the last case that there was no change in the size of the sella during the twelve years following operation. Radiographs were taken as part of the follow-up examination in a considerable number of patients. Dr. Sosman very kindly forwarded some interesting reports of his observations in comparing the recent radiographs of patients who reported at the Brigham Hospital with those taken before operation. In several cases, without any recurrence of visual symptoms over periods of from eight to sixteen years, there was no increase in the size of the sella, and, what is more interesting, it had sometimes become smaller and had recalcified, so that the posterior clinoid and dorsum sellæ were denser than formerly. This occurred after partial excavations of solid tumours, and it is a valuable indication that the residual tumour within the sella is quiescent. Recalcification of an atrophic sella is, of course, also frequently seen after successful operations in cases of intracranial tumour associated with chronic high intracranial pressure.

In one or two cases, on the other hand, also without any recurrence of visual symptoms, the recent radiograph showed increased erosion of the sellar floor and of the basisphenoid and adjacent parts of the petrous ridges, indicating a slow downward extension of the tumour.

Post-operative Mental Symptoms, Late Epilepsy, and Psychosis.—It might be supposed that mental symptoms would be apt to occur after transfrontal operations, owing to the possibility of traumatizing the frontal lobe, and that the post-operative scarring might, later on, start epileptic attacks. The risk of these complications is, in fact, negligible with the extradural approach, as the frontal lobe is protected by the dura. Mental disturbances sometimes occur during the first few days, especially after transfrontal operations, but they are usually mild and transient and are in most cases due to blood-clot formation or to cerebral œdema associated with an intracerebral extension of the adenoma. It happens that the most severe maniacal disturbances occurred in two patients with advanced lesions who had had transsphenoidal operations.

Psychotic symptoms, which necessitated the patients' transfer to an asylum, appeared in 5 cases, usually some years after transsphenoidal operations and in patients of advanced years. They were occasionally associated with evidences of a progressive dyspituitarism. In the other patients, in view of their advanced age, it is assumed that the symptoms, in the absence of any obvious association with the pituitary tumour, were ascribable to degenerative vascular changes.

E. REMARKS ON THE TREATMENT OF CHROMOPHOBE ADENOMATA

1. Operation *v.* X-ray Therapy.—At this point, having described the early and late results of operation and the effects of X-ray therapy, a few general remarks may be made on the relative merits of these two forms of treatment, concerning which there is no unanimity of opinion. Some authorities recommend one and some the other almost exclusively, but many believe that there are indications for both methods. Certain conclusions, which are based on the results of this follow-up study, will now be drawn without attempting to review the opinions of others.

As regards the immediate danger of surgical treatment, a risk of less than 5 per cent, or 2·4 per cent as it was in Cushing's hands during the last ten years of the series, is not a serious argument against operation, the purpose of which is to preserve vision. A study of the fatal cases showed that in many of them the lesion was already far advanced, and it is unlikely that they would have received any worth-while benefit from either form of therapy had they survived. Even X-ray treatment is not without danger, for it occasionally produces an exacerbation of symptoms from swelling of the tumour, which may necessitate urgent operation.

The principal argument against operation seems to be based upon the general belief that the risk is considerably higher than 5 per cent, as it undoubtedly is in the hands of the inexperienced, and that X-ray therapy, with its negligible immediate risk when carefully supervised, is therefore preferable. The opinion of a radiologist or of a surgeon is naturally influenced to a large extent by his estimate of the surgical risk; but it is equally important to take into consideration the probable amount of visual recovery and, what is apt to be forgotten, the likely duration of the improvement, for this must eventually form the chief basis of comparison.

As regards the effects of X-ray therapy, one fact stands out from the statistical analysis of this series—namely, that radiation quite definitely retards the growth of the tumour in many cases. This is shown by the reduction in the incidence of recurrences at the five-years interval in cases in which operation was supplemented by X-ray therapy. It might even be inferred from the absence of recurrence in many cases after ten years and longer—cases which could be regarded as 'cured'—that the growth of the tumour is sometimes completely arrested by the supplementary radiation; this assumption is hardly justifiable, however, as the same can happen after operation alone.

A belief in the beneficial effect of post-operative X-ray treatment has been expressed at various times by different authorities from their clinical impressions of individual cases, but no evidence so conclusive as that presented in this paper seems to have been published; and, indeed, the conclusions that were drawn from these results came as a surprise. Impressed no doubt by the cases that had failed to show any improvement after X-ray treatment alone, and also by the absence of any improvement in the early results in the cases that received

post-operative treatment, Dr. Cushing long held the opinion that radiation had little or no effect on chromophobe adenomata.

In 1932 he stated[10]: "So far as concerns radiotherapeusis, at least in the case of chromophobe adenomas (the chromophil adenomas in our experience appear to be more definitely susceptible to radiation), it is safe to say that it will come to be discarded, so soon as neurosurgeons as a class perfect themselves in details of the operative procedure. It may reasonably be assumed that in those clinics where radiation for these lesions is still routinely advocated, the surgical results have been poor and the mortality disturbingly high." Dr. Cushing later amended this view, at least as regards post-operative radiation, when it was realized how many cases showed favourable late results.

The beneficial effect of post-operative X-ray treatment suggests that the chromophobe cells are damaged, although this has never been proved histologically. It is not possible to say whether irradiation produces merely a retardation (or cessation) of the tumour growth, which is all that matters in post-operative cases after the sella has been emptied; or whether there is, in addition, any considerable reduction in the size of the tumour, which is the essential of any form of treatment.

A few striking successes have been reported by various observers, and there is no doubt that radiation alone sometimes produces a remarkable and even complete restoration of vision. This was observed after the treatment of recurrences in two instances (*Cases* 16 and 17) in this series, and it may be assumed there had been sufficient reduction in the size of the tumour to relieve the chiasmal compression.

Some writers, impressed by similar successes, suggest that X-ray therapy should replace operation as the routine treatment in most, if not all, cases, but no sufficiently large series, observed over a long enough period of time, has yet been published. It is not so much a question of showing that X-ray therapy can be effective in some cases, for this is already known, as of estimating its comparative value and its limitations. This could only be done from a series of patients, long observed, all of whom had been treated in the first instance by radiation.

Dyke and Hare[15] recently published an admirable and unbiased report from the radiologist's standpoint, of their experiences with X-ray therapy in 63 cases of pituitary adenoma treated at the Neurological Institute of New York during the years 1929 to 1937. Their carefully controlled observations extended over periods of from one to seven years after treatment. Of the 38 patients with chromophobe adenomata, 8 showed marked improvement, 2 slight improvement, in 10 vision remained unchanged, and in 18 it became worse.

Thus vision was improved in only 26·4 per cent of the 38 patients, and in 47·3 per cent it became worse. It may be noted in passing that, in accordance with the experience of others, their results were better in cases of acidophil adenoma, for of the 25 acromegalic patients treated vision was improved in 10 (40 per cent) and became worse in 6 (24 per cent). If the chromophobe cells are more embryonic in type than the acidophil cells, it is strange that they should react less favourably to radiation. Dyke and Hare conclude that irradiation is a valuable form of treatment in many cases of pituitary adenoma, regardless of the histological type, and they are in agreement with other writers who favour a preliminary trial of X-ray therapy in all cases.

A comparison of the above results of modern X-ray therapy in expert hands with those of operation in this series shows that there is an improvement in vision in only 26·4 per cent of cases treated by radiation as against 68 per cent of all cases coming to operation (cf. *Table III*), and that vision became worse in 47·3 per cent of cases as against only 5·4 per cent after operation.

X-ray therapy alone, therefore, is inadequate in many cases—a conclusion which was reached by Dyke and Hare from the results in their own series. In searching for an explanation of these failures they suggest, as others have done, that there are probably three main reasons for the absence of improvement after X-ray therapy: (1) The visual fibres are already permanently damaged; (2) The tumour is largely cystic (as it was in 17 per cent of cases in this series); and (3) Some solid tumours are radioresistant (this is shown, in this series, by the rapid reappearance of symptoms in certain cases after a successful operation plus X-ray treatment).

Some authorities, recognizing the failure of radiation in some cases and its success in others, recommend that treatment should begin with a preliminary trial of X-ray therapy, unless the patient is in immediate danger of losing vision, the progress of the treatment being carefully controlled by frequent perimetric examinations. If vision continues to decline, or even if it remains stationary, operation is then advised. Sosman (1937)[24] recommends that "irradiation be given a thorough trial in all cases with at least a six-month period of observation and treatment, and that surgical removal be limited to those patients whose tumours fail to respond to the irradiation".

He further states, from his recent experience of treating all cases of pituitary adenoma with irradiation before resorting to surgery, that "the results indicate that satisfactory remissions of symptoms and signs will be obtained in over 50 per cent of patients with chromophobe adenomas". My personal belief is that valuable time would thereby be lost in the majority of cases which do not respond adequately and ultimately require operation. The strong possibility of further deterioration in vision, the increased surgical risk after an unsuccessful trial period of radiation, and the fact that much less improvement is likely to follow the delayed operation, more than counterbalance the elimination of the immediate surgical risk in others.

It is sometimes claimed that improvement in endocrine disturbances, which usually occurs after X-ray therapy, is a point in its favour, but any form of treatment is clearly defective if only one in four of the patients is benefited as regards vision, this being the only important indication for therapy. The only cases in which X-ray therapy may justifiably be tried are those in which there is only slight impairment of visual acuity, without clear-cut field defects and without pallor of the optic disks, but it is just this type of case in which the operative risk is very small; in the more advanced cases it is a dangerous waste of time.

The restoration of vision is an urgent mechanical problem, because it is impossible to predict whether the visual damage is still recoverable and when it will become permanent. The chiasmal compression should therefore be relieved completely and without delay. Only in this way is it possible to minimize the amount of permanent optic damage and so obtain the maximum improvement. In the writer's opinion those who continue with X-ray therapy so long as there is no further loss of vision, may deprive the patient of ultimate restoration of vision

which would, and often does, follow operation in such cases. Again, there is the chance that the clinical diagnosis, which cannot be verified pathologically, is incorrect, and that the tumour belongs to a group which is insensitive to radiation and should, therefore, be operated upon immediately.

How permanent are the results of X-ray therapy, even in the most successful cases, is as yet unknown. Some of the cases reported in this paper show that the duration of recovery may become progressively shorter after successive X-ray treatments, and be very much shorter than that following subsequent operation. It has been shown that radiation may produce adhesions between the tumour and important surrounding structures, and also that it may fail to prevent an intracranial extension of the adenoma, in spite of temporary improvement in vision. The results should be evaluated only after a period of at least five years.

It appears from the literature that opinions expressed in some papers had been prejudiced in favour of radiation by comparing its effects with the results of operation as given by Cushing[7] in his report published as long ago as 1922. Before that time the usual treatment was transsphenoidal operation alone, and, as described in a previous section, the majority of cases had a recurrence of symptoms and died within two or three years. The striking improvement in the late results of the modern transfrontal operation plus X-ray treatment requires no further comment.

In the writer's opinion, therefore, the chiasma should be liberated by immediate operation in order to obtain the maximum recovery of vision, and the possibility of recurrence should be minimized by irradiating what little tumour tissue remains after radical excavation. The risks of operation are slight, and, while good results can be obtained by X-ray therapy in a few cases, the results of operation are very much better. The aim of treatment is not to prevent the onset of blindness, but to restore vision.

2. Transfrontal *v.* Transsphenoidal Operations.—As regards the question of surgical approach, the merits of the transfrontal and transsphenoidal operations have already been dealt with and it remains only to summarize the views expressed concerning the indications for each. The factors to be considered are the operative mortality, the degree of visual recovery, and its probable duration.

There is no essential difference in the operative mortality of the two procedures. The danger of meningitis after the transsphenoidal operation is counterbalanced by the slight risk of clot formation after the transfrontal operation.

The early results show that, on the whole, the visual recovery is more nearly complete after transfrontal operations, especially in cases with bitemporal hemianopia. In this series, the types of cases in which there were consistently better results after transsphenoidal operations were those with homonymous hemianopia due to tract involvement or with bilateral central scotomata, i.e., cases which are likely to have a prefixed chiasma and therefore insufficient space in front of the chiasma for access to the intrasellar tumour by the transfrontal approach. It is suggested that this is the chief indication for the transsphenoidal operation. Another suggestion, which will be referred to later in the discussion on clot formation, is that the transsphenoidal approach should be used in patients of advanced years or with high blood-pressure owing to the risk of continued bleeding after intracranial operations.

The presence of a cyst is sometimes regarded as an indication for the transsphenoidal route, but this point hardly arises as it does not seem possible to diagnose the consistency of the tumour before operation. Neither is the size of the sella of any importance, judging from the results in this series. Cairns[3] suggested that people over 60, and also those in whom the optic nerves have been severely damaged for a long time, should have the transsphenoidal operation, as the optic nerves are more likely to recover when the compression is released slowly.

The late results are better after the transfrontal operation, due, no doubt, to the more radical excavation which it is possible to obtain by that route. The late results of the transsphenoidal operation when followed by X-ray therapy are, however, sufficiently good in most cases to warrant the use of that procedure when it is likely to produce a much better early result, i.e., in cases in which there is probably a prefixed chiasma.

It is suggested, therefore, that the transsphenoidal operation should not be abandoned altogether, and that it is preferable to the transfrontal procedure in patients having a greatly ballooned sella with homonymous hemianopia or with bilateral central scotomata, and also in those patients who are over 60 years of age or have a high blood-pressure.

F. THE TREATMENT OF RECURRENCES

The early and late results so far considered have been those of the primary operations only. The operations in patients who had previously had surgical treatment in other clinics have, for the purpose of this paper, been regarded as primary operations, although they were actually secondary interventions.

What is the outlook for those patients who return with a recurrence of symptoms, and can anything worth while be done for them? Do the chromophobe adenomata show any evidence of increasingly rapid growth, or do they tend to become quiescent? What is the usual result of a secondary operation, and should recourse be had to radiation rather than surgery? The answers to these questions involve a consideration of: (1) The mortality rate of secondary operations; (2) A comparison between the results, both early and late, of primary and secondary operations; (3) The results obtained by X-ray treatment alone, and the possibility that the delay caused by a trial period of X-ray treatment may have a detrimental effect on the result of a subsequent operation should it become necessary; (4) The prognosis in untreated cases as regards the onset of blindness or of disabling intracranial symptoms and the probable duration of life.

There were 44 operations in the clinic for recurrence of symptoms (cf. *Table II*); most of them were transfrontal procedures after 1928, during the latter part of the series. It is important to review this large number of secondary operations in detail, for the satisfactory results are not generally known. In the earlier years of the series, the majority of patients who returned with symptoms of recurrence, usually within a short time of operation, had no further treatment; the end-results of these cases, and of the patients who refused a secondary operation, provide a good indication of the prognosis in untreated cases (p. 901). A smaller group of 14 patients had X-ray treatment alone, the results of which have already been described (p. 870).

The results of the 4 *secondary transsphenoidal operations* were disappointing. In 1 patient, a hæmorrhagic cyst, which refilled six months after the first operation

in 1916, was again emptied by the transsphenoidal route, and there was a marked recovery of vision. This improvement, however, fell off again as the cyst rapidly refilled, and, although another exploration and evacuation two weeks later again relieved the symptoms, meningitis developed and the patient died after another two weeks. In the other 3 patients, the loss of vision was already very far advanced and no worth-while improvement was obtained. The technical difficulties of making a re-entry along the transsphenoidal route are great, and the results are so disappointing that, during the first few years of the series, the cases with recurrence of symptoms were not submitted to a second operation, nor did the rapidity with which the symptoms returned, within from two to three years in most instances, appear to make further intervention worth while.

The later adoption (*c.* 1928) of the transfrontal operation, however, opened up a new avenue of approach, so that patients with recurrences after a transsphenoidal operation could receive the benefit of a second and more radical removal of the tumour. It was also found that the transfrontal operation, unlike the transsphenoidal operation, can be repeated several times (cf. *Case* 20 *below*) without any technical difficulty from adhesions or the risk of meningitis, and with an even greater and more lasting amelioration of symptoms.

The lateral flap and the subtemporal decompression operations, although sometimes carried out during the same hospital admission as one of the other procedures, have, for convenience, been regarded as secondary operations in *Table II*. The subtemporal decompression is merely a palliative procedure for the relief of headaches due to an intracranial extension of the tumour. The lateral flap operation was usually supplementary to the transfrontal procedure for the removal of an extension into the temporal lobe (e.g., *Case* 6).

There were, as shown in *Table II*, 33 *secondary transfrontal operations* for recurrences in 29 patients (2 patients each had 3 secondary operations), with 1 post-operative fatality due to the formation of an extradural and suprasellar clot in a patient with a hæmorrhagic cyst; this was one of the earliest transfrontal operations in the series, and the clot was not recognized in time to save the patient. The mortality rate of secondary procedures is, therefore, even less than it is after primary operations. The intervals between the operations varied from three months to six years.

The *early results* were highly successful after 23 of the secondary transfrontal operations; there was an improvement in vision after 20 of them, and on the other 3 occasions the failure of vision was arrested before there was any serious impairment. The improvement after 4 of these 23 operations was definitely greater than had been obtained after a previously successful transsphenoidal operation (e.g., *Case* 22 *below*). In 9 instances the restoration was as complete as it had been after the primary operation; in 10 others the improvement was less complete.

Of the remaining 10 operations, 3 were followed by a further loss of vision, due to the formation of post-operative clots (which happened to be associated with cysts in two instances, e.g., *Case* 26 *below*); in 6 cases with advanced symptoms, these progressed to incapacitation within a short time; and 1 patient died as stated above.

It is quite clear from a review of these cases that certain factors are likely to influence unfavourably the early results of secondary operations. They are:—

a. A delay of six months or longer after the reappearance of symptoms. Operation should be carried out immediately a recurrence reveals itself, and

certainly within three months of the onset of symptoms, in order to give a reasonable chance of good recovery. In this respect, secondary operations appear to be different from primary operations, after which a highly successful result may be obtained when the symptoms have been present for a considerably longer period.

b. An advanced visual defect, which makes it unlikely that there will be much recovery after a secondary operation, but the further progress of symptoms may be arrested. There were manifestations of a large intracranial extension in 5 of the 6 patients in whom the secondary operation was a failure.

c. Post-operative blood-clot formation, which occurred after 5 operations, in 4 of which it was associated with a cystic tumour; this important complication will be referred to later (p. 893).

The *late results* of secondary operations may be summarized briefly by the statement that in 22 patients (i.e., excluding the 6 patients with advanced symptoms in whom operation had failed to arrest the progress of the disease) the duration of freedom from symptoms was in all cases longer than it had been after the previous operation; in two-thirds of them there has been no evidence of further recurrence up to the present time, while in one-third symptoms of recurrence have appeared once again, but always after a longer interval than on the previous occasion. The symptoms appeared, on an average, from one to four years after the primary operation.

After the secondary operations the majority of patients continued to be free from symptoms for a period of from five to twelve years, and in those with a second or third recurrence the symptoms did not usually appear until from four to seven years after operation. It is assumed that this improvement in the late results after secondary operations is due partly to the more radical removal of tumour in those cases which had had transsphenoidal operations previously, and also in certain cases to the additional effect of X-ray treatment when it was given for the first time after the second operation. Correspondingly good results were obtained, however, in patients who previously had had transfrontal operations.

It is important to note that there was no evidence of increasingly rapid growth of the tumour in patients who had two or more operations, except in a few instances in which the lesion was already too far advanced for any improvement to occur after operation. This was well shown, for instance, by a comparison of the results following the primary and secondary operations in a group of 8 patients who had never had X-ray treatment; and, again, the results in a group of 4 patients who had already had X-ray treatment after the first operation.

These 4 patients show that a more lasting effect is obtained after the secondary operation, even when the recurrence followed what is regarded as the optimum initial treatment, i.e., transfrontal operation plus X-ray therapy. Furthermore, there are 2 patients who are known to have had three operations each, and 2 who have had four operations each, either at the Brigham Hospital or, since Dr. Cushing's retirement, in other clinics, and in every case the interval of freedom before the reappearance of symptoms became progressively longer after each operation.

In 14 patients with recurrences X-ray treatment was given an adequate trial, but the results (p. 870) on the whole were less good than after secondary operations.

Three case reports will now be given briefly to illustrate some of the various results obtained in the treatment of recurrences. The following patient had his first operation twenty-two years ago, and although the treatment of the subsequent

recurrence was delayed so long that the immediate result was disappointing, he is still leading an active life.

Case 19.—H. F. P., aged 47 years, the president of a manufacturing company (P.B.B.H. Surg. No. 2502), was admitted on *Feb.* 17, 1915. He had noticed a slight impairment of vision for one year. Examination revealed a temporal paracentral scotoma in each eye,

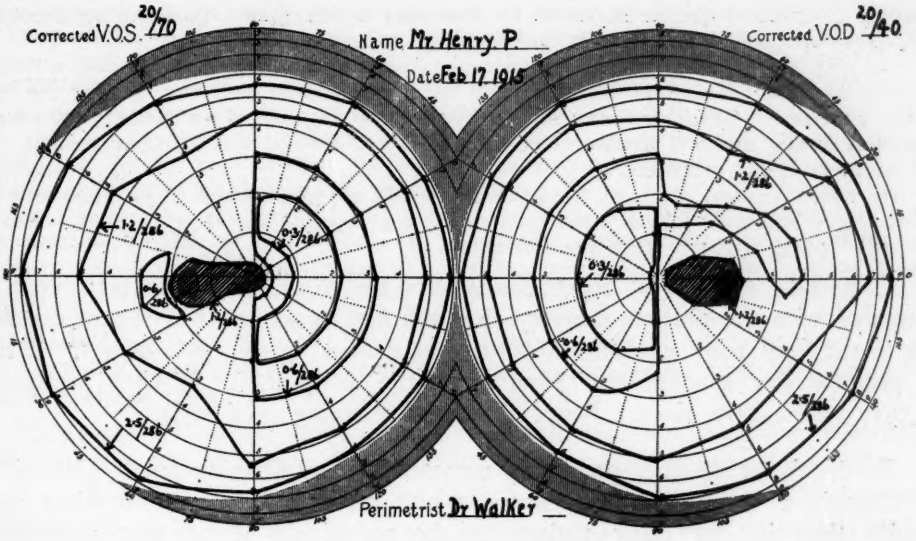


FIG. 630.—*Case* 19. Fields of vision on admission.

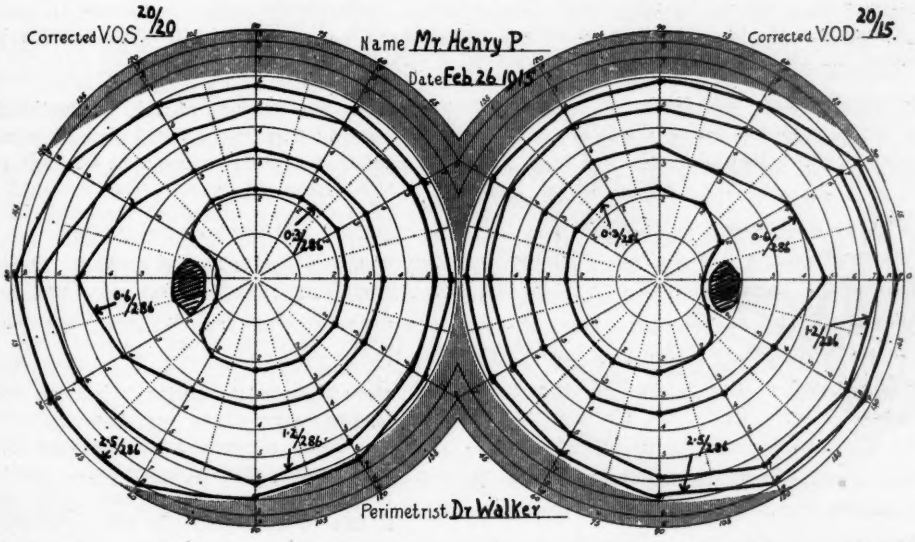


FIG. 631.—*Case* 19. Fields one week after a transsphenoidal operation, showing the restoration of normal vision (cf. *Fig.* 630).

with preservation of fairly intact peripheral fields (*Fig.* 630); V.O.S. 20/70 and V.O.D. 20/40; slight pallor of the optic disks and a slightly enlarged sella (20 × 12 mm.).

On *Feb.* 19, 1915, a soft adenoma was radically excavated by the transsphenoidal route. The scotomata promptly disappeared and he was discharged with normal vision and full fields (*Fig.* 631).

He remained symptom-free until the spring of 1917, i.e., two years after operation, when his vision began to fail again, with predominantly inferior temporal paracentral defects. A secondary transsphenoidal operation undertaken in another clinic in *May*, 1918, accomplished little, if anything, and a course of X-ray treatments in the autumn of 1918 was followed by only slight improvement. He then had several radium applications between *December*, 1920, and *June*, 1921, but without any apparent benefit.

He was re-admitted to the Brigham Hospital on *Aug.* 5, 1921, i.e., after there had been a slowly progressive decline in vision for four and a half years. Examination showed a complete bitemporal hemianopia with V.O.S. 20/70 and V.O.D. 20/40.

On *Aug.* 9, 1921, a right transfrontal exploration disclosed a large cyst below a bulging diaphragma sellæ. The fluid was evacuated and the cyst wall collapsed, leaving the optic nerves quite free. Conditions remained unaltered up to the time of his discharge two weeks later, but during the next twelve months the right eye showed a slight improvement. He had no more X-ray treatment.

He wrote on *Nov.* 12, 1936, to say that he could see well enough to play golf and still conducts his business without interruption. He last reported on *May* 21, 1937, when he was still "going strong" at 70 years of age.*

COMMENT.—The slow improvement after the treatment of the recurrence, as compared with the prompt recovery after the first operation, was almost certainly due to the long delay resulting in permanent damage to the optic nerves. It may be assumed that a secondary operation on the reappearance of visual symptoms in 1917 would have given a better chance of retaining good vision.

In the following case, previously reported by Dr. Cushing (1930, *Case* 3)[9] as an example of a suprasellar adenoma, symptomatic recurrence took place more rapidly than in any other patient in the series. It shows that transfrontal explorations can be repeated on the same patient without any technical difficulty.

Case 20.—H. G., 43 years of age, a doctor's wife (P.B.B.H. Surg. No. 27759), was admitted on *Dec.* 7, 1926. She had observed a cloudiness in the vision of the left eye for five months and a temporal defect in the right eye for one month. Examination showed bitemporal field defects with a relative central scotoma in the left eye, the vision of which was reduced to 20/70, and a clean-cut temporal hemianopia in the right eye with 20/30 vision. The sella was normal. A right transfrontal exploration was made on *Dec.* 13, 1926, and a small solid suprasellar adenoma was cleared out by suction (*Fig.* 632). Vision was immediately restored to 20/20, with full fields in both eyes.

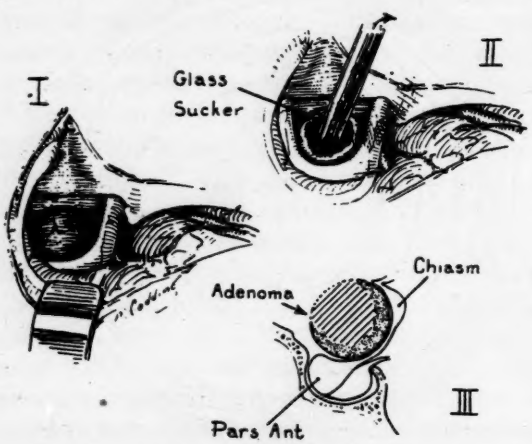


FIG. 632.—*Case* 20. A schematic drawing showing: I, Position of the suprasellar adenoma; II, Treatment of the lesion by suction; and III, Estimated size and position of the suprasellar tumour, and extent of the extirpation (shaded).

Four months later, because of a rapid recurrence of symptoms, she was re-admitted and the visual fields were found to be essentially the same as on the previous admission, although the acuity was reduced to 20/200 in the left eye and 20/30 in the right eye. On *May* 7, 1927, the right transfrontal flap was re-elevated and the soft, solid adenoma, which had the same appearance as at the first operation, was again excavated intracapsularly. As before, the patient was discharged with normal vision and fields.

* He reported again on *April* 30, 1938. Vision remains unchanged and general health is good.

All went well for six months and then she noticed a return of the haziness in the left eye. When admitted for the third time on *Jan.* 11, 1928, the visual fields again showed essentially the same defects as before. On *Jan.* 17, 1928, the chiasmal region was re-explored, and on this occasion it was possible to dislodge and remove the tumour entirely except for a small fringe alongside the right optic nerve. Once again operation was followed by full recovery of vision.

The interval of freedom was much longer this time, and it was not until the summer of 1930, i.e., two and a half years after the previous operation, that she noticed a return of the temporal defect in the left eye; this slowly progressed, and when she was re-admitted on *April* 30, 1932, the visual fields were much the same as on previous admissions. The sella, however, now showed an increase in size, with destruction of its floor and an irregular soft tissue mass projecting into the sphenoidal air sinus. On *May* 4, 1932, i.e., two years after the first symptomatic evidence of this recurrence, the transfrontal flap was, for the fourth time, elevated and the adenoma was again excavated by suction, but on this occasion the restoration of vision was much less complete.

In *August*, 1934, she reported that her vision had shown no further deterioration and that she was leading an active life. In September, however, she complained of nasal obstruction which was found to be due to a tumour, supposedly cancer, in the nasopharynx. This was treated in another clinic, during *October* and *November*, 1934, by local applications of radium and deep X-ray therapy. A slough formed with perforation of the hard palate. She remained well until *Sept.* 23, 1935, when a left hemiplegia suddenly appeared and she died the following day. A post-mortem examinaton showed basilar meningitis and thrombosis of the right middle cerebral artery.

COMMENT.—This case shows that the chiasmal region can be exposed repeatedly, even after intervals of only a few months. So few adhesions remained inside the dura that no difficulty was encountered even at the fourth operation. The opening in the capsule of the adenoma had closed in completely after each operation, leaving only a small scar on the surface of the tumour, which otherwise showed no trace of having been excavated previously. There does not appear to be any tendency for the presence of a temporary opening in the capsule to predispose to an intracranial spread of the tumour, as has often been supposed, in the event of its continued growth. The tumour, in fact, eventually extended downwards into the nasopharynx rather than upwards into the cranial chamber, though it was originally suprasellar in situation, and its capsule had been opened on four separate occasions.

The completeness of the tumour removal was about the same each time, and yet the interval of freedom became progressively longer after each operation. It is possible, in view of the usually beneficial results in other cases, that, had X-ray treatment been given after the earlier operations, the recurrences would have been much longer in appearing, or might even have been delayed indefinitely. Death was clearly precipitated by the use of radium, which had caused a slow necrosis of the surrounding tissues and finally meningitis.

The next patient, one of the most successfully treated recurrent cases, shows what may be accomplished by the combination of operation and X-ray treatment.

Case 21.—J. F. I., a machinist, aged 34 years (P.B.B.H. Surg. No. 27274), was admitted on *Sept.* 23, 1926. For about twelve months there had been a progressive, failure of vision, more especially in the left eye, lassitude, and occasional bouts of severe frontal headache and vomiting. He had not been able to read for two months. Examination showed a predominantly bitemporal defect with V.O.S. 12/200 and V.O.D. 20/70, pallor of both optic disks, and a moderately enlarged sella.

On *Sept.* 29, 1926, by the transsphenoidal route, a large amount of the soft adenoma was excavated. There was an immediate recovery of vision to 20/40 in each eye and

considerable expansion of the temporal fields. He did not have X-ray treatment. The lassitude disappeared, he felt well; and soon returned to work.

Three months later he had a bout of severe generalized headache with vomiting, and the left eye became totally blind. He never had any headache again and his health remained good.

In *September*, 1927, i.e., one year after operation, he noticed a recurrent failure of vision in the temporal field of the right eye, and he was re-admitted to hospital two weeks later. There were no other symptoms. On examination, the left eye was blind from primary optic atrophy; the right eye had a visual acuity of 20/70, clean-cut temporal hemianopia, and primary optic atrophy with a superimposed papillœdema of 3 dioptres.

A right transfrontal exploration on *Oct.* 4, 1927, revealed a large mass of tumour which was projecting above the sella and had destroyed the left optic nerve. The usual radical excavation of the adenoma was followed by rapid recovery of vision in the right eye to 20/20, with return of sight in the temporal field. He had several X-ray treatments during the next year.

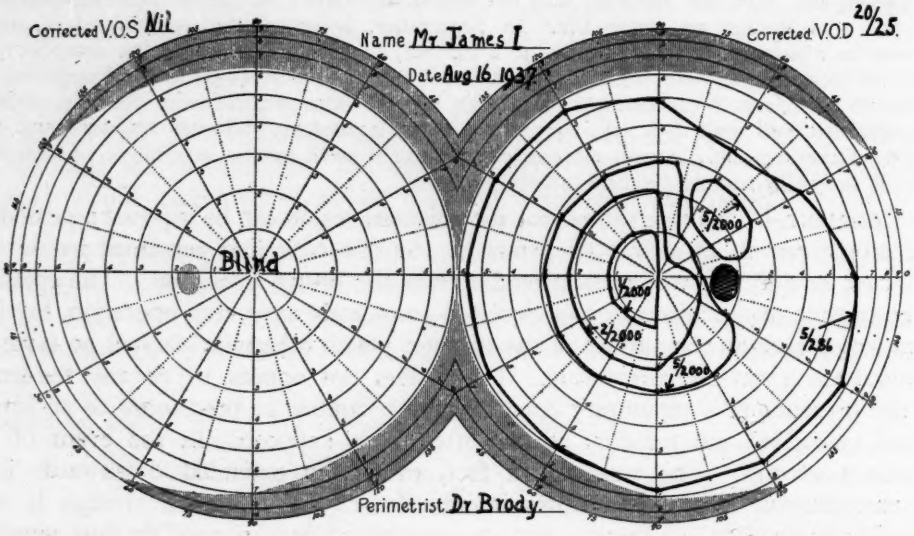


FIG. 633.—*Case* 21. Note the expanded fields of vision with normal acuity in the right eye, which condition has remained unchanged since its restoration after a secondary operation ten years previously. The left eye had been blind for nine months before the secondary operation.

He wrote in *October*, 1936, to say that he was well and at full work. He reported at New Haven on *Aug.* 16, 1937, and the extremely satisfactory present state of vision in the right eye, then ten years after the secondary operation, is shown in *Fig.* 633. His health is excellent. He does fine work in a machine shop and has not missed a day's work since his last operation.*

COMMENT.—The final result is gratifying in view of the large size of the adenoma which had already destroyed the left optic nerve and had produced signs of increased intracranial pressure before the second operation. The conditions in this instance were perhaps the most favourable for such a satisfactory late result, i.e., a transsphenoidal operation without X-ray treatment, and then the more radical transfrontal operation plus X-ray treatment. Even so, such a good ten-year result was hardly to be expected in a case with papillœdema and bouts of generalized headache and vomiting. After such an experience one would hesitate to refuse to any patient a secondary operation even when the symptoms strongly suggest an intracranial extension.

* He wrote again on *Oct.* 21, 1938, to say that his vision and health remain good.

G. CYSTS

The chromophobe adenomata were largely or entirely cystic at the primary operations in 45 of the 260 patients, i.e., 17 per cent. Twenty-nine of these 45 patients had transsphenoidal operations. A number of cases in which a small cyst was present in the centre of a predominantly solid tumour are not included.

Two varieties of cysts may be distinguished as regards the appearance of the fluid. The more common hæmorrhagic cyst contains a turbid, dark-red or almost black fluid debris, which is no doubt the result of recent degenerative changes within the tumour. The less frequent type of cyst contains clear xanthochromic fluid, sometimes so pale that it is almost colourless. The proportion of hæmorrhagic to xanthochromic fluids is about 2 to 1. Intrasellar cysts are usually unilocular, but those that extend outwards into the Sylvian fissure are sometimes multilocular. The cyst wall consists of a layer of tumour tissue of varying thickness.

It may be noted here that cysts are comparatively rare in acidophil adenomata; the adenoma was cystic in only 4 of the 67 surgically verified cases of acromegaly, i.e., 6 per cent. All the cysts were hæmorrhagic and none of the patients had X-ray treatment before operation.

1. Intrasellar Cysts.—A review of the mode of onset and the duration of the symptoms in these cases has not revealed any feature by which cystic and solid adenomata can be distinguished before operation. A sudden exacerbation of the visual defect or a transitory, unusually severe headache does not occur any more often with cysts than with solid tumours; in both the symptoms as a rule are gradually progressive. In a few cases the known duration of visual impairment was only one or two months, but this is frequently due to the fact that a progressive hemianopia is often not observed until central vision is seriously affected, by cystic and solid tumours alike. The incidence of cyst formation does not appear to be influenced by previous radiation; only two patients with cysts had had X-ray treatment before operation.

The early and late results following the evacuation of cysts do not show any striking difference from those after the intracapsular excavation of solid tumours. When operation was not followed by X-ray treatment, the late results showed the same considerable variation as in cases with solid tumours. Thus, in the majority of cases there was a recurrence of symptoms within a few years after operation, while in a few instances there has been no recurrence over periods of ten or fifteen years. In others, however, the visual defect, which had shown a marked improvement immediately after operation, recurred much sooner than in any of the cases with solid tumours, owing to rapid refilling of the cyst; when this occurs it is difficult to deal with.

Post-operative X-ray treatment apparently reduced the incidence of recurrences, just as in the cases with solid adenomata. These cysts are surrounded by a layer of tumour tissue similar to, but usually less thick than, that which remains after the radical excavation of solid tumours. A recurrence of symptoms may, therefore, be due to the growth of solid tissue from the cyst wall or to re-accumulation of cyst fluid, so that all patients with cystic tumours should receive X-ray treatment after operation. There were, for instance, 2 patients in whom solid tumours were found at the secondary operations five and seven years after large cysts had been emptied at the primary operations; neither of them had had X-ray treatment.

Six of the patients with hæmorrhagic cysts had secondary operations after varying intervals; in 5 of them the cysts again contained hæmorrhagic fluid, while in the remaining case the fluid was yellow. None of them had had X-ray treatment. Cysts which contain yellow fluid show less tendency to recur than do those with hæmorrhagic fluid. In addition to the 45 primarily cystic cases, there were 3 patients who had cysts containing yellow fluid at secondary operations; all had solid tumours at the primary operations which were followed by X-ray treatment.

In the discussion on the results of secondary operations it was stated that a cyst was commonly present in those cases with a disappointing degree of visual recovery (p. 884). Nevertheless, a secondary operation must be advised immediately a patient who previously had a cystic tumour shows symptoms of recurrence, because delay is one of the chief factors against obtaining a good result and X-ray therapy alone is not likely to produce any benefit.

It is, perhaps, unfortunate that a pituitary tumour may become cystic because of the tendency for cysts to refill soon after evacuation, and also because persistent oozing into a hæmorrhagic cyst may lead to blood-clot formation around the chiasma. It was, for instance, necessary to make a re-exploration within two weeks of a transsphenoidal operation in 4 patients, all with cystic tumours, in whom it seemed likely, because of a recurrence of the visual defect or of headache, that the cyst had refilled.

It is difficult to believe that a cyst, even if it were possible to diagnose it clinically, is an indication for the transsphenoidal approach, as is sometimes stated, on the supposition that the immediate collapse of a cyst liberates the chiasma more completely than does the partial removal of a solid tumour. The attempt to empty a constantly refilling cyst was directly responsible for meningitis which caused one of the 2 post-operative deaths among the 44 secondary operations.

The following case is an example of how hæmorrhagic cysts can be treated more successfully by a transfrontal operation.

Case 22.—W. A. K., aged 50 years, a school teacher (P.B.B.H. Surg. No. 29991), was admitted on *Oct.* 30, 1927.

For nine months he had observed progressive bitemporal visual defects and for two months occasional transitory diplopia when looking at distant objects. There had been no headaches. Examination revealed an almost complete bitemporal hemianopia, V.O.S. 20/70, V.O.D. 20/50, and a large sella.

On *Nov.* 11, 1927, a large cyst containing some 15 c.c. of blackish fluid was emptied by the transsphenoidal route; no solid tumour was seen. There was an immediate expansion of the temporal fields and the visual acuity improved to 20/40 in both eyes. He remained well until *November*, 1928, when he noticed a return of the visual defect, which progressed steadily during the next five months, but he was entirely free from headache.

When he was re-admitted in *April*, 1929, acuity was reduced to V.O.S. 20/100 and V.O.D. 20/70, and the bitemporal hemianopia was again almost complete. On *May* 2, 1929, by the transfrontal route, a large hæmorrhagic intrasellar cyst containing dark blood was evacuated. Continued oozing from the cyst was very troublesome, but it eventually stopped after temporarily placing pledgets of wool soaked in Zenker's fluid within the cyst cavity and electrically coagulating the capsule. The cavity was drained for twenty-four hours through the outer angle of the supra-orbital incision. This procedure was followed by a prompt expansion of the temporal fields, with vision restored to 20/40 in both eyes.

The patient came to New Haven for personal examination on *Oct.* 29, 1936. He was in excellent health and had been leading a normal life since the secondary operation seven and a half years previously. His vision was perfect: 20/20 with a full field in both eyes. He had not had any X-ray treatment, apart from a single session immediately before the first operation.

COMMENT.—The chief methods of dealing with the tedious oozing from hæmorrhagic cysts have been Zenker-fixation of the cyst lining, electrical coagulation around the margins of the opening in the capsule, and drainage to prevent the formation of a suprasellar and subfrontal clot. These methods can be used only with an intracranial operation, which alone affords direct access under vision to the cyst. The good result in this patient is typical of that obtained after secondary operations in many others.

2. Intracerebral Cysts.—As in the case just cited, most of the 45 pituitary cysts were encountered in adenomata confined within the stretched framework of the sella. In a few instances, however, a large intracranial extension had become predominantly or entirely cystic. Such large intracerebral cysts were sometimes connected with the intrasellar portion of the tumour by a comparatively narrow neck, as shown in 7 instances either at operation or autopsy. If the pituitary origin of these cysts has not been suspected, they can easily be mistaken at operation for gliomatous cysts because of their situation within the brain. The prognosis is good if the cyst is evacuated and X-ray treatment is given. Three other patients, with intrasellar cysts, had definite symptoms of an intracerebral extension which may also have been cystic, although it was not proved.

The following case is an example of a cystic intracerebral extension in the frontal lobe; the sella was not enlarged and the origin of the cyst was not at first suspected.

Case 23.—M. L. B., aged 35 years, a housewife (P.B.B.H. Surg. No. 37032), was admitted on *Aug.* 4, 1930.

Apart from occasional discomforts she had been free from symptoms until six weeks before admission, when she began to have bursting frontal headaches, vomiting, periodic diplopia, failing memory, and blurred vision, but no subjective hemianopia.

Examination revealed slight mental slowness, early papillœdema of 1 dioptre in both eyes, V.O.S. 20/200 with a lower temporal field defect, and V.O.D. 20/25 with a full field.

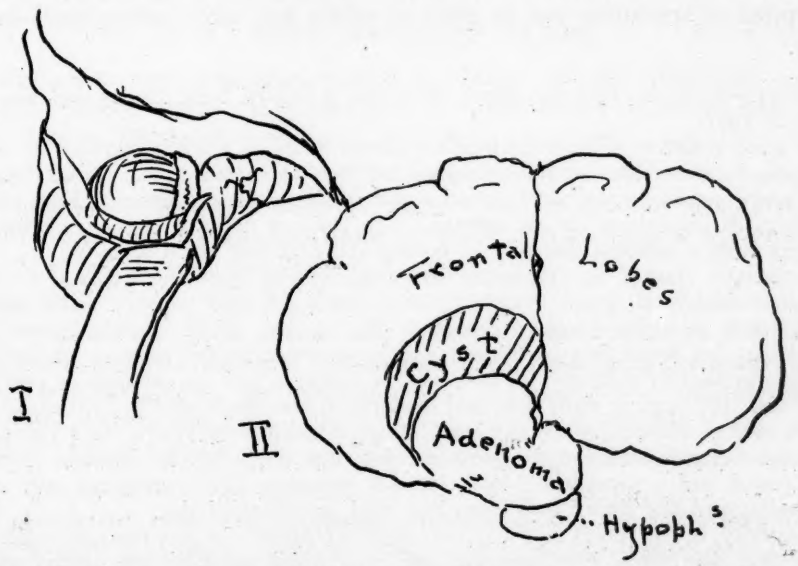


FIG. 634.—*Case* 23. Operator's sketches to show: I, Intrasellar portion of the adenoma protruding upwards on the inner side of the right optic nerve; II, Intracerebral extension in the lower part of the right frontal lobe covered by a large superficial cyst.

The right pupil was larger than the left; both were fixed to light but reacted briskly on convergence. The sense of smell was normal. X-ray examination showed signs of increased intracranial pressure; the sella was indistinct and atrophic, but it was not expanded or deformed.

The situation of the tumour remained undetermined until ventriculography, on *Aug.* 12, 1930, showed a deformity of the anterior horn of the right ventricle which suggested a subfrontal tumour of uncertain type. A large right transfrontal bone-flap was reflected immediately, and exploratory punctures into the frontal lobe encountered resistance at a considerable depth. The dura was opened along the sphenoid ridge and when the frontal lobe was elevated, a soft, greyish tumour was found bulging upwards on the left side of the right optic nerve (*Fig.* 634). The tumour was presumed to be a suprasellar adenoma with an intracerebral extension; this was proved by immediate supravital examination. The under surface of the frontal lobe was removed, exposing a cyst which contained at least 10 c.c. of xanthochromic fluid and a large mural tumour. The solid tumour, which extended downwards under the chiasma, was cleared out by suction.

All the symptoms disappeared after operation, vision improved to 20/50 with an almost fully expanded field in the left eye, and to 20/15 in the right eye. A course of X-ray therapy was given after operation. She wrote in *August*, 1935, i.e., five years after operation, to say that she had had no further trouble and was leading a normal busy life.

COMMENT.—The soft suprasellar adenoma had grown upwards into the lower part of the right frontal lobe, its superficial (intracerebral) portion had become cystic, and its chief manifestations, including the X-ray appearances, were those of increased intracranial pressure. The same line of extension was taken in several instances by adenomata which, however, remained solid and produced the symptoms of a deep frontal tumour. When a tumour which has an unusual appearance in this situation is approached from the convexity of the cerebral hemisphere, the possibility that it may be an adenoma should always be borne in mind. It is in such cases that rapid histological diagnosis during the operation is so helpful, as it proved to be in this particular instance.

In the next case, which came early in the series, a large temporal lobe cyst was emptied at operation, but its place of origin was quite unsuspected before the autopsy.

Case 24.—E. M. C., aged 34 years, a housewife (P.B.B.H. Surg. No. 15494), was admitted on *Nov.* 2, 1921.

She gave a history of amenorrhœa for eleven years, a marked increase in weight for eight years, frequent olfactory hallucinations for four years, attacks of loss of consciousness for two years, severe generalized headaches and vomiting, failing memory, slow cerebration, and changes in disposition for six months. She had not noticed anything wrong with her sight apart from occasional difficulty in finding the next line when reading.

Examination showed an incomplete left homonymous hemianopia with a sector spared in the lower fields and spared maculæ; V.O.S. 20/40, V.O.D. 20/50; acute papillœdema of 3 dioptres in the right eye and 1 dioptre in the left eye; slight exophthalmos of the right eye; a slight left lower facial weakness and hyperactive tendon reflexes on the left side. The sella was slightly enlarged. There was no anosmia and no oculomotor palsy.

On *Nov.* 17, 1921, a right temporal exploration was made and a transcortical incision entered a cyst at a depth of about 2 cm. A large quantity of yellow fluid was evacuated. The patient became comatose the same evening, but there was no paralysis; the wound was re-opened and a superficial blood-clot was removed. This produced only temporary improvement, and she lapsed into coma and died on the third day.

At autopsy, it was found that a second large extradural clot had formed which extended forwards over the frontal lobe, and that the cyst, which occupied the greater part of the temporal lobe, had originated from a pituitary tumour, the solid portion of which formed the medial wall of the cyst, in the region of the uncus (*Fig.* 635).

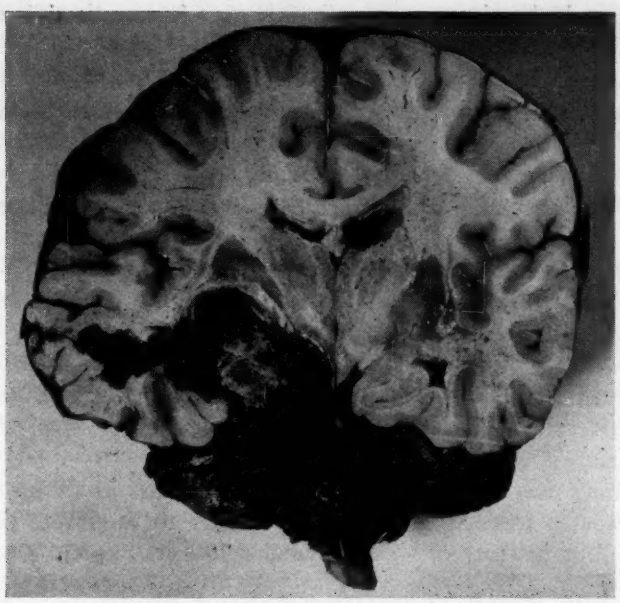


FIG. 635.—*Case* 24. Coronal section of brain showing the collapsed wall of a large temporal-lobe cyst, the line of the incision through the temporal cortex, and a mural mass of solid adenoma near the midline. The intrasellar portion of the tumour does not appear in this section. Note the absence of deformity of the third ventricle.

COMMENT.—So much has been learned since 1921 about intracerebral cysts, the behaviour of pituitary tumours, the value of rapid histological diagnosis, and the recognition of post-operative clot formation, that the outcome in this case would at the present time probably have been different.

H. POST-OPERATIVE CLOTS

In this series the most important complication of the transfrontal approach to pituitary tumours was the formation of a blood-clot within a few days of operation. If the clot is not removed it is likely to cause fatal cerebral compression, though in the less severe cases recovery may occur after a slow convalescence but often with considerable loss of vision. There is little doubt that smaller clots may remain unrecognized and are the cause of some of the disappointing results as regards visual recovery after transfrontal operations.

There are two situations in which post-operative bleeding is prone to occur, (1) over the convexity of the frontal lobe underneath the bone-flap, and (2) below the frontal lobe from the cavity of the tumour, the former being the more common. The two varieties of clot, the extradural and the suprasellar, produce different clinical manifestations which must be recognized at an early stage if the clot is to be removed and the bleeding controlled before irreparable damage to the optic nerves, or even a fatality, has occurred.

1. Extradural Clots.—The bleeding usually occurs from the surface of the dura, but it may also come from the deep surface of the bone-flap or from the meningeal vessels at the base of the flap. The blood collects over the frontal lobe and signs of compression appear, the most important of which is drowsiness. This

goes on to coma which, if not soon relieved, may have a fatal issue. Œdema of the eyelids and face is a common and important sign. There is rarely any preliminary slowing of the pulse; the first change is usually an increased rate in the terminal stages of coma. Signs of hemiparesis are rarely present, and appear only at a very late stage. The suspicion that extradural hæmorrhage is occurring after a transfrontal operation depends, therefore, entirely upon increasing unresponsiveness and drowsiness and usually also swelling around the eyes, whereas clot formation after a lateral osteoplastic flap is more easily recognized from the early appearance of progressive hemiparesis along with drowsiness.

When a patient becomes either drowsy or unduly restless after a pituitary operation there should be no delay in re-elevating the bone-flap, even when the diagnosis is uncertain. The recognition and removal of a clot before the stage of deep coma is usually followed by prompt recovery of consciousness and a smooth convalescence unless a second clot forms within another day or two, and the prognosis for vision is good.

The story may now be told of a woman of 66 years in whom the tendency to clot formation was so marked that it was necessary to re-elevate the flap on three successive days, but in spite of this the final result was good.

Case 25.—C. P. G., aged 66 years, a housewife (P.B.B.H. Surg. No. 36485), was admitted on *May* 14, 1930.

There had been a slowly progressive failure of vision in the left eye for two years, and she had recently noticed a bitemporal hemianopic constriction of the visual fields. There had never been any headache. Examination showed complete bitemporal hemianopia, V.O.S. 5/200 and V.O.D. 20/30. The sella was considerably enlarged.

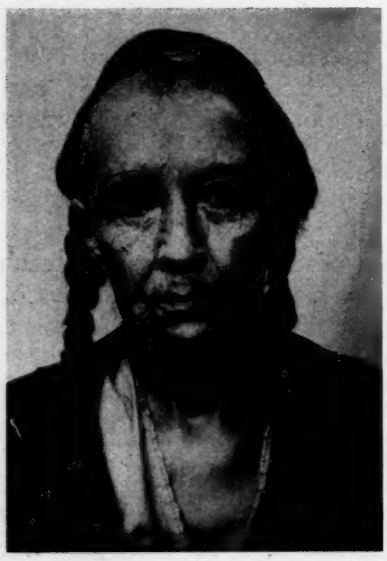


FIG. 636.—*Case* 25. The patient on discharge two weeks after four transfrontal operations within four days, showing the well-healed scar.

On *May* 24, 1930, a right transfrontal exploration was made and a large, soft adenoma was excavated by suction. She made a good immediate recovery, but on the evening of the following day, i.e., thirty hours after operation, she lapsed into coma. An immediate re-elevation of the bone-flap revealed a large extradural clot; this was removed, and there was a temporary improvement. On the evening of the following day she began to show signs of early hemiparesis; the bone-flap was again elevated, i.e., fifty-four hours after the primary operation, when a second extradural clot was removed, after which there was again a slight improvement, although she remained drowsy. Once again her condition became rapidly worse, and the following morning Dr. Cushing, fearing yet another clot formation, decided to re-open the wound for the third time, i.e., seventy-two hours after the first operation, although she was by then quite comatose and indeed, as I well remember, almost moribund. This time, however, no clot was found, but she began to respond the same evening and steadily improved thereafter (*Fig.* 636).

Her vision showed considerable improvement both before and after returning home. She wrote in *July*, 1936, six years after the operation, to say that her general health was still good at 72 years of age, and that her eyesight was perfect. She never had X-ray treatment.*

* The patient wrote again on *Dec.* 16, 1938, to say that her vision and health remain good.

2. Suprasellar Clots.—Clots of this variety are more apt to be missed than an extradural clot because there may be no drowsiness. The blood slowly accumulates from continued oozing within the cavity of the excavated tumour, or more often a hæmorrhagic cyst, and then it extends upwards around the chiasma and optic nerves and forwards underneath the frontal lobe. The chiasma and optic nerves are compressed and there is a rapid decline in vision, which is the more striking should it occur after a definite immediate post-operative improvement.

This may be the only clinical evidence of a suprasellar clot, although the patient is sometimes rather irritable and restless, or dull and even drowsy, and there may be swelling of the eyes. It is desirable, therefore, to determine if there is any recovery of vision by testing the acuity and fields as soon as possible after the patient recovers from the anæsthetic, and to repeat the examination daily, as any subsequent failure of eyesight may not be noticed by the patient. Any considerable decline in vision is sufficient indication for immediate re-exploration.

Failure to detect or to recognize the importance of declining vision within a few days of operation is doubtless responsible for some of the disappointing results after transfrontal operations. The prognosis as regards vision, even when the suprasellar clot is promptly removed, is less good than after removal of extradural clots, because the accompanying œdema of the frontal lobe restricts the exposure and adds to the difficulty of clearing the clot and securing hæmostasis without damaging the obscured optic nerves.

The following case illustrates the serious effect that a chiasmal clot may have on vision and how easy it is to overlook its presence in the early stages.

Case 26.—J. J. McM., aged 25 years, a clerk (P.B.B.H. Surg. No. 22416), was admitted on *Oct.* 18, 1924, with the complaint of progressive failure of vision in both eyes of eight months' duration. He never had any headaches. Vision was reduced to finger counting in the nasal field of the left eye and to 20/70 with a temporal paracentral scotoma in the right eye.

On *Nov.* 1, 1924, a fairly radical removal of a succulent adenoma was made by the transsphenoidal route after which there was a marked improvement in vision. On his discharge the right eye had 20/20 vision with a full field, and the left eye had recovered 20/50 vision with a residual central scotoma, but the peripheral field was full.

One year later vision began to fail again and, in spite of several courses of X-ray treatment, on his re-admission on *Jan.* 10, 1928, the left eye was blind and vision in the right eye was reduced to 20/50 with complete temporal hemianopia.

On *Jan.* 20, 1928, a transfrontal exploration was made and about 10 c.c. of xanthochromic fluid was evacuated from an intrasellar cystic adenoma. This was followed by an immediate improvement of vision in the right eye, but it fell off again to 5/200 by the tenth post-operative day, when the bone-flap was re-elevated. This revealed a subfrontal hæmatoma, which was removed, and a tensely refilled intrasellar cyst, which was again emptied and drained. There was an immediate improvement in vision, which, however, again failed to less than 2/200. A second re-elevation was made four weeks after the first operation, and it was found that the cyst had again refilled. No improvement followed this operation, and blindness rapidly supervened. He is still in good general health, nine years later, although quite blind.

COMMENT.—In this case, one of the most disappointing in the series, the refilled cyst and suprasellar clot had not caused any general disturbance, and had remained unsuspected until there was what proved to be an irrecoverable failure of vision.

3. Incidence of Clot Formation.—There were 30 re-elevation operations in 23 patients, with sometimes 2 and even 3 such operations in one patient. A clot was present on 20 occasions (in 16 patients). In the remaining 10 explorations no clot was present, and it was assumed that the symptoms had been caused by cerebral œdema, which was sometimes associated with an intracranial extension of the adenoma. Blood-clot formation had therefore occurred in 16 of the 115 patients who had primary or secondary intracranial operations, i.e., 14 per cent.

Five of the 6 patients who died after intracranial operations (cf. *Table II*) had had the bone-flap re-elevated for suspected clot formation. A clot was present in 3 of them, and the symptoms in the remaining 2 instances were due to cerebral œdema, associated with an intracranial extension of the adenoma.

On 18 of the 20 occasions on which a clot was present it was chiefly situated under the bone-flap, though in 2 instances it was associated with a suprasellar clot; in the remaining 2 cases the clot was situated only around the chiasma. Clots may, therefore, be present in both situations, and it is important, after removing a clot from under the bone-flap, to explore the chiasmal region also.

The most common time for re-elevation, whether there proved to be a clot or only œdema, was from twenty-four to forty-eight hours after operation. The times varied, however, from as early as six hours to as late as ten days, but only 5 of the 30 re-elevations took place later than seventy-two hours after operation. Evidence of clot in pituitary cases occurs later, therefore, than after lateral flap operations for gliomas or meningiomas, in which clots are usually recognizable within twenty-four hours, due to the early onset of hemiparesis.

In spite of constant vigilance, the great difficulty of recognizing the early stages of extradural clot formation after pituitary operations is shown by the following case.

Case 27.—N. McK., aged 71 years, the oldest patient in the series (P.B.B.H. Surg. No. 34353), was admitted on *July* 5, 1929. He had a typical bitemporal syndrome with a moderately enlarged sella and a blood-pressure of 180/90.

On *July* 12, 1929, a fairly tough adenoma was excavated by the transfrontal approach. Slight restlessness and confusion immediately after the operation had entirely disappeared within twenty-four hours, and he was doing very well until the third night, when he became less responsive, and within six hours became semicomatose. There was no hemiparesis. The bone-flap was immediately re-elevated, and a large extradural clot 3 cm. in thickness was removed; the chiasmal region was quite clear. There was no improvement, however, and he died twelve hours later.

Before leaving the question of post-operative clots, it should be mentioned that their incidence at the Brigham Hospital was perhaps higher than in some other clinics. Blood-clots were removed from 1 in 7 of the patients who had transfrontal operations. It seems to me, judging from my experience as resident in Cushing's clinic and in other clinics, that there are three main reasons for the considerable number of re-elevation operations in this series: (1) Dr. Cushing believed in re-elevating the osteoplastic flap as soon as any suspicious signs appeared, because the effects of frontal lobe compression are apt to be very indefinite and difficult to distinguish from those of œdema before it is too late. He undoubtedly reopened cases with small clots which others might have left to resolve spontaneously, though after a stormy convalescence. Whereas a negative exploration never did

harm, critical symptoms due to a progressive clot may advance with unexpected rapidity. (2) Drainage, either of the tumour cavity or of the extradural space under the bone-flap, was rarely used. (3) The operations were all performed under local anæsthesia, so that the blood-pressure was apt to be lower while hæmostasis was being established before closure, than when general anæsthesia is used; this possibly enhanced the likelihood of bleeding with the restoration of normal pressures. Modern devices to prevent the formation of extradural clots have more recently come to be employed.

I. NASOPHARYNGEAL EXTENSIONS

An extension of the tumour through the base of the skull into the nasopharynx was noted in 8 cases, in only 3 of which was it already present at the time of the first hospital admission. In the remaining 5 cases it did not appear until some years later (e.g., *Case* 20) or was discovered post mortem. Although it is possible that small extensions remained unsuspected in a few other cases, it seems that the projection of pituitary tumours downwards through the base of the skull is less common than was once generally supposed.

A pituitary adenoma which has eroded through the basisphenoid into the nasopharynx has usually already destroyed the sella and has also extended upwards sufficiently to produce visual disturbances. A study of the 8 cases in the series indicates that treatment should consist of relieving the chiasmal compression by a transfrontal operation, without excavating too deeply into the sella, and in relying on X-ray therapy to check the growth of the nasopharyngeal part of the tumour, which must be left undisturbed owing to the possibility of infection. The danger of extensive necrosis and meningitis following the local application of radium has already been referred to (p. 875). That the outlook is by no means hopeless in these cases is shown by the following case report.

Case 28.—S. I., aged 52 years, a housewife (P.B.B.H. Surg. No. 35532), was admitted on *Dec.* 30, 1929, with the complaints of continuous nasal discharge and failure of vision.

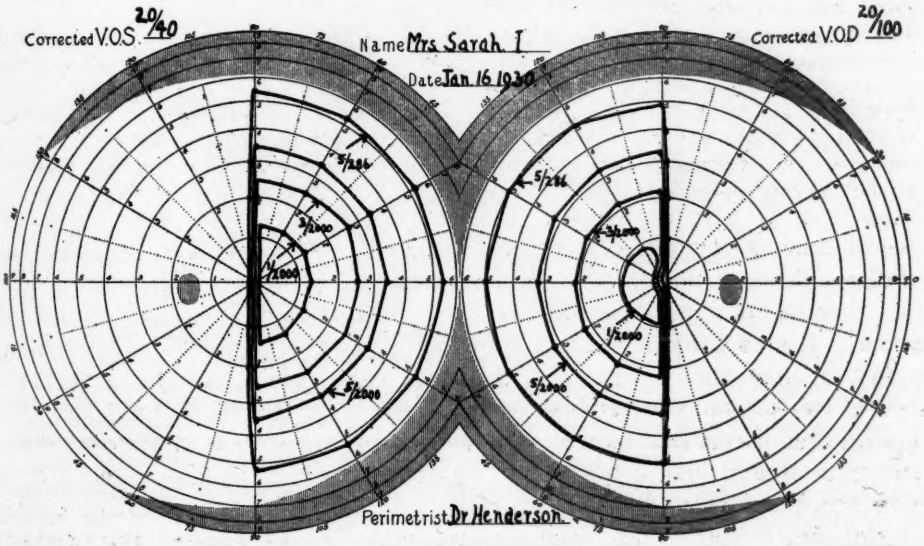


FIG. 637.—*Case* 28. Fields of vision before transfrontal operation on a patient with a large nasopharyngeal extension of a chromophobe adenoma.

Menstruation ceased suddenly twelve years before admission and there was a rapid increase of about 90 lb. in weight during the next three years, after which her weight remained stationary. For five years she had noticed a progressive loss of vision in both temporal fields, especially the right. During the last three years there had been a frequent mucoid

FIG. 638.—*Case* 28. Radiograph showing complete destruction of the sella and the shadow (arrows) of the tissue mass projecting into the nasopharynx.

nasal discharge and a "continuous cold", which troubled her more than the loss of vision. For two years she had experienced occasional slight frontal headaches.

Examination showed an obese woman weighing 255 lb. There was complete bitemporal hemianopia (*Fig.* 637), V.O.S. 20/40, V.O.D. 20/100, and bilateral primary optic atrophy.

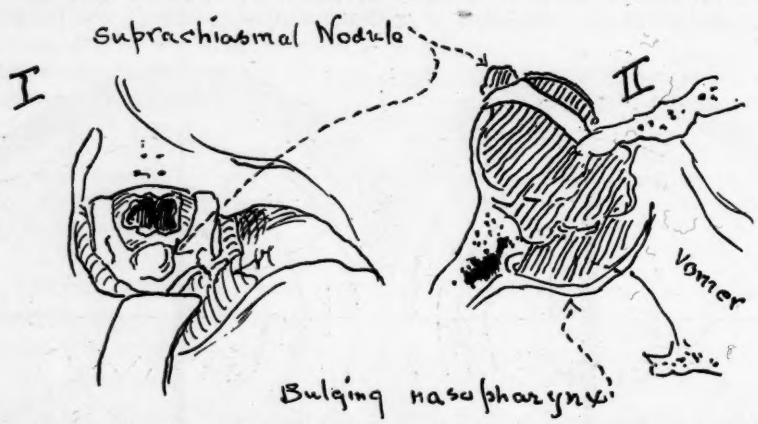


FIG. 639.—*Case* 28. Operative sketch showing: I, Liberation of left optic nerve after excavation of adenoma and the small extracapsular extrusion overlying the chiasma; II, Diagrammatic representation of the site and presumed extent of the partial excavation in the large retropharyngeal mass.

A large, soft mass palpable to the finger could be seen in the roof of the nasopharynx by posterior rhinoscopy. X-ray examination showed complete obliteration of the sella and the presence of a rounded mass projecting down into the nasopharynx (*Fig.* 638); the destruction of the basisphenoid was clearly seen stereoscopically.

On *Jan.* 18, 1930, a right transfrontal operation was carried out for the immediate preservation of vision; a huge adenoma, which was protruding upwards between the optic nerves, with a small supradiaphragmatic extrusion overlying the chiasma, was partially extirpated by suction (*Fig.* 639).

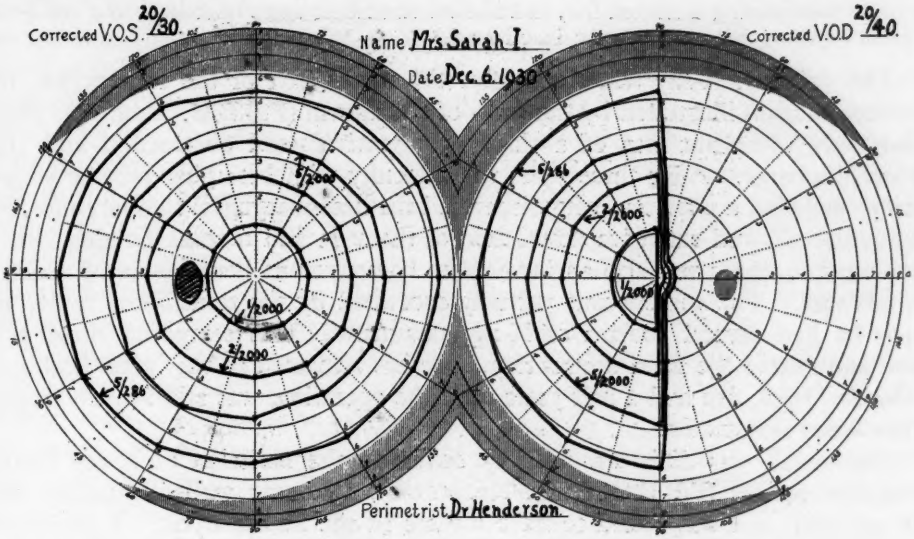


FIG. 640.—*Case* 28. Fields of vision eleven months after those in *Fig.* 637, prior to the several courses of X-ray therapy for a nasopharyngeal extension.

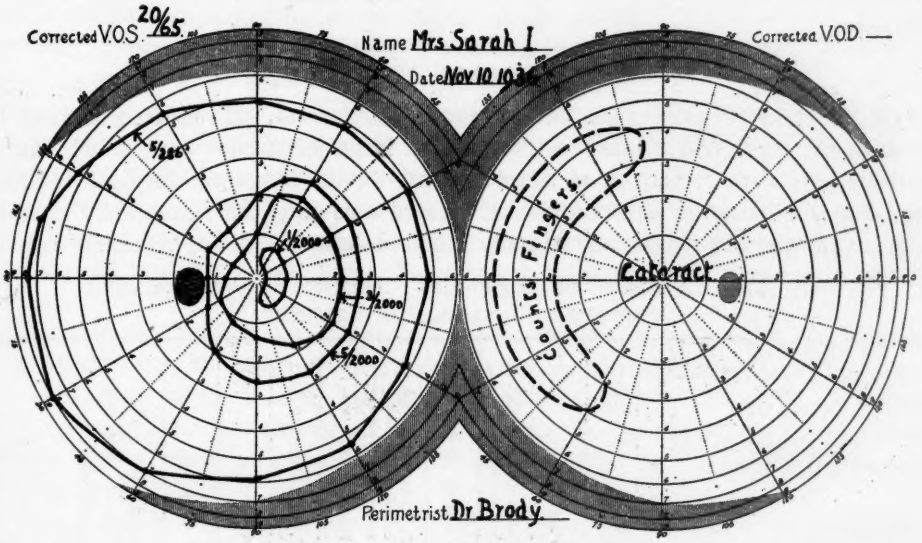


FIG. 641.—*Case* 28. Visual fields six years after those in *Fig.* 640, showing decline in vision due to the cataracts.

Vision improved steadily for some time after the operation and the fields taken when she reported nearly a year later, in *December*, 1930, are shown in *Fig.* 640. There was, however, no improvement as regards the nasal obstruction and chronic discharge. X-ray treatment was accordingly started and she received about nine courses of treatment during the next four years; the last course was given in *April*, 1935.

I had the opportunity of examining her at New Haven on *Nov.* 10, 1936, and, recalling the large size of the post-nasal mass in 1930, found her in far better health than was anticipated. There was still slight nasal discharge, but it had become much less since the X-ray treatments and breathing was easier. There had been some decline in vision (*Fig.* 641) due to the presence of bilateral cataracts, advanced in the right eye and commencing in the left. She was leading a normal life, had had no headaches since operation, and the growth appeared to have been completely inactivated.*

The value of X-ray treatment, after the upper part of the tumour has been removed, is again illustrated by the story of a salesman (P.B.B.H. Surg. No. 38431), whose only complaint was of a slowly progressive nasal obstruction and slight mucoid discharge. After three years the difficulty with breathing became so great that he consulted a physician who discovered the nasopharyngeal tumour, and X-ray examination showed extensive destruction of the sella and a mass bulging into the nasopharynx; there was also an incomplete homonymous hemianopia of which he was unaware. The tumour was partially excavated by the transfrontal route, after which he had several courses of X-ray treatment. This served to preserve his vision and relieve the nasal obstruction. He has remained in very good health, and in *October*, 1936, five and a half years after the operation, was still actively engaged in his usual occupation.

The result was different, possibly owing to the omission of X-ray therapy, in another patient (P.B.B.H. Surg. No. 41560), a woman who had failing vision and epistaxis, and was found to have a mass in the nasopharynx. A transfrontal operation was followed by marked improvement for twelve months, when symptoms of a progressive intracranial extension appeared. She became blind and bedridden, with complete hemiplegia, and succumbed four and a quarter years after the operation.

J. INTRACRANIAL EXTENSIONS

Of the 260 patients with chromophobe adenomata, 50 showed during the first hospital admission clinical evidence of a large extrasellar extension; similar manifestations were present in 16 other patients for the first time during subsequent admissions for symptomatic recurrence. Extensions into the intracranial chamber (cf. p. 814), whether projecting laterally into the temporal lobe, upwards into the

Table XII.—CHROMOPHOBE ADENOMATA: NUMBER OF PATIENTS WITH SYMPTOMS OF INTRACRANIAL EXTENSION

TIME OF ONSET OF SYMPTOMS	HEADACHE	VOMITING	DROWSINESS, STUPOR, INCONTINENCE	FAILURE OF MEMORY	OLFACTORY HALLUCINATIONS	HEMIPARESIS	CONVULSIONS	PETIT MAL	POLYDIPSIA	DIZZINESS	BRADYCARDIA	TOTAL NUMBER OF CASES
Before operation	23	24	23	18	7	6	11	5	7	3	1	50
Recurrence after operation	11	5	12	3	3	12	6	3	—	1	1	16

* She reported at New Haven on *April* 29, 1938. There had been no progression of symptoms. V.O.S. 20/65; V.O.D. counts fingers.

basal ganglia, or forwards into the frontal lobe, produce symptoms closely resembling those of tumours of other kinds in the same situation. The common symptoms and their relative frequency are therefore enumerated in *Table XII* without further comment.

The Clinical Course in Advanced Cases.—The clinical course of patients who ultimately died from the effects of the adenoma shows that they fall into three approximately equal groups, each of which is associated with certain predominant symptoms according to the situation of the intracerebral extension. They are :—

a. Thalamic Extension, projecting upwards into the third ventricle.—The first symptom, apart from serious loss of vision, is usually failing memory or drowsiness. The patient soon becomes bedridden and stuporose, which is the outstanding feature of these cases, and the visual defect (usually bitemporal hemianopia) progresses to blindness in both eyes. Polydipsia or dizziness may be additional complaints. Death usually ensues from general weakness before headaches and vomiting become conspicuous symptoms.

b. Temporal Extension.—Homonymous hemianopia, which is the characteristic visual defect, frequently escapes the patient's attention, so that the initial complaint is often of severe headaches and vomiting due to the already high intracranial pressure (it is particularly with this type of extension that papillœdema occurs). There may also be drowsiness, olfactory hallucinations, generalized convulsions, and, in the later stages, hemiparesis.

c. Sylvian Extension.—The tumour grows in a lateral and upward direction, so that it destroys one optic nerve and occupies the region of the Sylvian fissure and the lower part of the frontal lobe. There is a variable combination of the manifestations which occur in the more clearly defined syndromes of the two preceding groups. Any one or all of the following principal symptoms may be present—stupor and mental deterioration, headache and vomiting, olfactory hallucinations, hemiparesis. The patient becomes bedridden, and death usually occurs before blindness supervenes (it is characteristic that good vision remains in the nasal field of the contralateral eye).

Occasionally an extension produces only isolated symptoms which do not give any indication of the position of the tumour, e.g., generalized headache and vomiting (cf. *Case* 23 with a frontal lobe extension), occasional convulsions, or petitmal attacks.

As regards the *duration of life* after the appearance of intracranial symptoms in untreated cases, the majority of patients soon become confined to bed because of drowsiness and stupor in the case of those with a thalamic extension, or because of hemiplegia and some degree of mental change (hemiplegia alone is exceptional) in those with a temporal extension ; in the latter cases severe bursting headaches are often a distressing feature.

The majority of the patients who died from the effects of an intracranial extension had had only a fragmentary removal of the tumour by the transsphenoidal route during the early years of the series ; this often gave some relief for a year or two and then the symptoms progressed, and the patients succumbed usually within two or three years of operation. Those patients who developed symptoms of recurrence after a longer interval following operation and were not treated again, usually died within twelve or eighteen months after the appearance of intracranial symptoms.

III. THE ACIDOPHIL ADENOMATA

Acidophil adenomata differ in several respects from those of the chromophobe variety. Their secretory activity, with excessive production of the growth hormone, usually evokes the systemic disorder known as acromegaly (Marie), long before the adenoma has attained a size sufficient to produce the local pressure effects which, as we have seen, are often the first indication of a chromophobe adenoma. Indeed, many acromegalics, in spite of severe and distressing constitutional symptoms, may escape entirely during a long life from the chiasmal symptoms so characteristic of the more common chromophobe tumours. Furthermore, it is generally conceded that they are far more susceptible to the therapeutic effects of irradiation.

In view of all this, while the surgical problem in the two pathologically distinct disorders differs fundamentally, the 67 examples in the series of surgically verified acidophil adenomata with acromegaly will be presented, so far as possible, on the same general plan as that adopted for the chromophobe lesions.

A. POST-OPERATIVE MORTALITY

In acromegaly, just as in thyrotoxicosis, the patient's general condition is frequently more important in estimating the surgical risk than are the possible local effects of the adenoma, whereas the non-secreting chromophobe tumour is only likely to be dangerous when there is a large intracranial extension. The effects of the secretion, especially on the cardiovascular system and on sugar metabolism, are often more serious than is suspected, and although its manifestations are usually quite noticeable during the phases of increased secretory activity, it is easy to overlook residual damage during the quiescent periods.

Not only does the systemic disorder add hazards to operative intervention, but the bony changes in the skull add to the surgical difficulties of approaching the adenoma either from below or above.

In the transfrontal operation, the enlarged frontal air sinus and the occasional presence of a massive intracerebral extension, which may be quite unsuspected, add considerably to the risk of that approach, because of the increased difficulty in obtaining adequate exposure of the chiasmal region without retracting the frontal lobe excessively and so producing severe and sometimes fatal cerebral œdema.

The mortality figures are shown in *Table XIII*. It is seen that the risk of the transsphenoidal operation (6·6 per cent) was only slightly greater than in cases of

Table XIII.—ACIDOPHIL ADENOMATA: NUMBER OF PATIENTS, OPERATIONS, AND POST-OPERATIVE FATALITIES

OPERATION	NUMBER OF PATIENTS	NUMBER OF OPERATIONS	POST-OPERATIVE DEATHS	OPERATIVE MORTALITY PER CENT
Transsphenoidal	60	60	4	6·6 per cent
Transfrontal	7	7	2	20·0 per cent
Secondary transfrontal	—	3*	—	
Total	67	70	6	8·6 per cent

* The 3 secondary transfrontal operations followed primary transsphenoidal operations.

chromophobe adenoma (5·3 per cent, cf. *Table II*). The transfrontal approach, on the other hand, is undoubtedly a more dangerous procedure in acromegaly, though an operative mortality rate of 20 per cent in a group of only 10 cases can hardly be compared with the much larger transsphenoidal series.

Three patients, who died on the second, third, and fourteenth post-operative days respectively, had advanced loss of vision and presumptive clinical evidence of a large intracranial extension, which in two of them was verified post mortem. Another patient, who had homonymous hemianopia and a low visual acuity in the eye on the side of the affected optic tract, was progressing well after operation until the sudden onset of hyperthermia which preceded his death on the fifth day. Post-mortem examination showed that the homonymous hemianopia was due to compression of the optic tract, without any extension into the temporal lobe (cf. p. 842); the cause of death in this case was obscure. The remaining two fatalities were due to hæmorrhage. One patient died seventy-two hours after a transfrontal operation from cerebral compression by a large unsuspected extradural blood-clot which was disclosed at autopsy. The other patient died during a transsphenoidal operation from uncontrollable hæmorrhage within the sella, the source of which was never determined; this was the only fatality in the entire pituitary series from hæmorrhage during the operation.

It is noteworthy that there were no deaths from meningitis, either early or late.

B. THE EARLY RESULTS OF OPERATION

In acromegaly the outstanding feature is a generalized tissue overgrowth which affects the internal organs, the skeleton, and the superficial soft tissues; it is the changes in the last which produce the well-known characteristic coarseness of the features and enlargement of the hands and feet after which the disease is named. This overgrowth may be so insidious that even the typical acromegalic changes in the patient's appearance long remain unobserved. That this can happen even to a physician has been recorded by Dr. Leonard Mark (1912)[19] in his interesting autobiography of an acromegalic. He suffered from various systemic effects of the disease for many years before he realised the nature of his malady, although it had been well known to his friends for a considerable time. "For some fifteen or twenty years, each day when I looked into the glass to brush my hair or to shave, there was a typical acromegalic literally staring me in the face. Yet I never recognized the fact."

It is a well-known feature of the disease that the visible effects of the growth secretion on the adult skeleton and cutaneous tissues may be so slight (but nevertheless unmistakable to the experienced observer) in comparison with the greater intensity of its effects on the internal organs, that the cause of the various subjective complaints, such as severe headaches, may long remain unrecognized. This is not likely to happen, however, when the activity of the adenoma precedes final closure of the epiphyses, for then the immediate response to the excessive growth hormone results in an accelerated increase in height which leads to gigantism.

Five of the 67 patients showed definite gigantism, which differs from acromegaly only in the age of onset of the malady. Their ages on admission varied from 21 to 25 years, but the markedly accelerated rate of growth had started between the ages of 13 and 17. Acromegalic gigantism is thus a rare condition,

and it may be of interest, therefore, to record briefly the history of two patients, both of whom happened to develop extensive loss of vision, which was their only serious complaint. They also illustrate the very satisfactory recovery of vision that was obtained in many of the cases in which the tumours, although still growing in size, had apparently ceased to produce a highly active secretion. The first patient, the longest surviving case in the entire series, had a transsphenoidal operation in 1913, whereas the second patient, one of the last cases in the series, had a transfrontal operation in 1930.

Case 29.—C. M. W., aged 24 years, a solicitor (P.B.B.H. Surg. No. 496), was admitted on *Oct.* 16, 1913, with the chief complaint of failing vision.

Seven years before admission, i.e., when 17 years of age, he began suddenly and rapidly to grow taller. Within a year his height increased from 5 ft. 8 in. to 6 ft. 2 in., and during the next four years there was a more gradual increase to 6 ft. 4 in. During the last two years there was no increase in height, but his hands and feet became very large. He had also noticed a gradual protrusion of the lower jaw during these seven years. For the last three years he had observed a gradual failure of vision, especially in the right eye, with constriction of both temporal fields, and also slight failure of memory, lethargy, and diplopia. He never had headache.

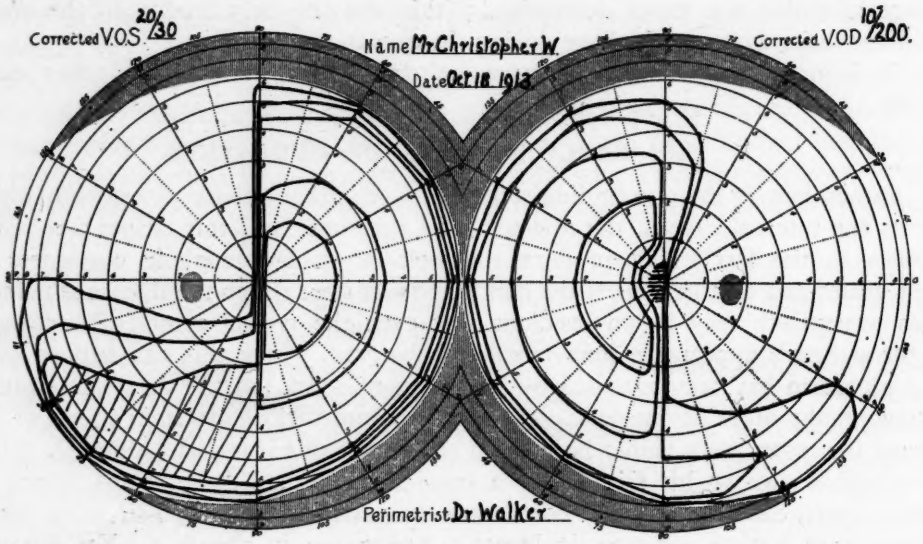


FIG. 642.—*Case* 29. Visual fields before partial removal of a solid acidophil adenoma by the transsphenoidal route.

On examination, he was a man of gigantic proportions with the typical features of acromegaly. He was 6 ft. 4 in. in height and weighed 238 lb. (17 stone). Visual tests showed bitemporal defects, V.O.S. 20/30 and V.O.D. 10/200 (*Fig.* 642). There was pallor of the optic disks and an enlarged sella (23 × 18 mm.).

On *Oct.* 20, 1913, Dr. Cushing exposed the floor of the sella by the transsphenoidal approach and partially removed a solid tumour. When the patient was discharged ten days later, vision had already improved to 20/20 in the left eye and 20/70 in the right eye, with considerable expansion of the temporal fields.

He subsequently saw active service with the British Army in France and was an instructor in signalling. He later wrote from his home in England to say that the malady appeared to be stationary.

Prof. Hugh Cairns very kindly examined him for me on *Nov.* 11, 1936, and the following is an abstract of his report: "He is remarkably well and full of gratitude. The only thing that seems to trouble him is failure of libido (absent since before operation).

Vision gradually returned in temporal fields during the next few years (after operation) with exception of upper quadrants (*Fig.* 643); it is now stationary. No headache. Never any glycosuria; urine is sugar-free. The features are very strongly acromegalic. Height 6 ft. 4¾ in. in shoes. Weight 20 st. 7 lb. in indoor clothes. Blood-pressure 154/110. He manages a large poultry farm." He never had X-ray treatment.

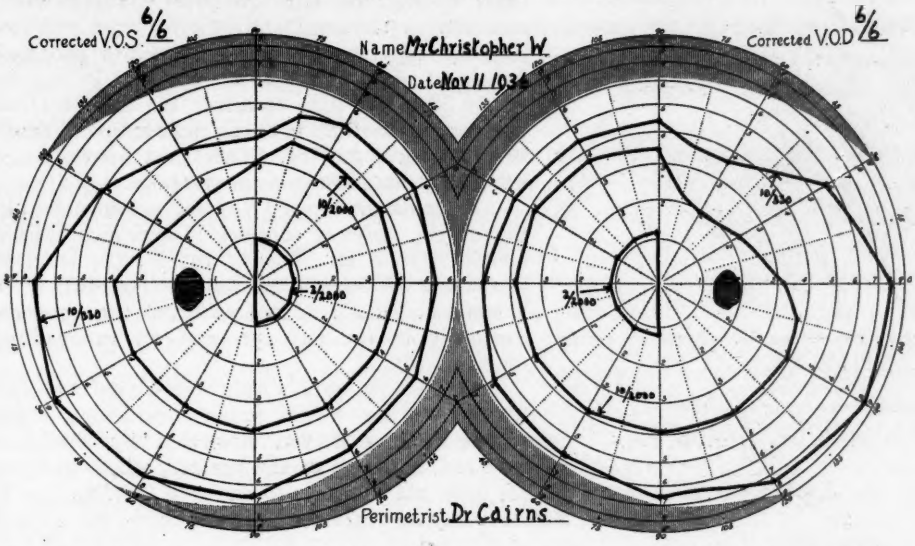


FIG. 643.—*Case* 29. The fields of vision twenty-three years later, the patient having received no further treatment in the interval.

COMMENT.—This case is typical of the good and enduring results that may be obtained by operation when the clinical picture is dominated by the local pressure effects rather than by the secretory effects of the adenoma. An equally good result might possibly have been obtained by irradiation had the efficacy of X rays on acidophil adenomata then been known.

Case 30.—H. G. H., aged 24 years, a farmer (P.B.B.H. Surg. No. 37799), was admitted on *Dec.* 8, 1930, with the complaint of failing vision.

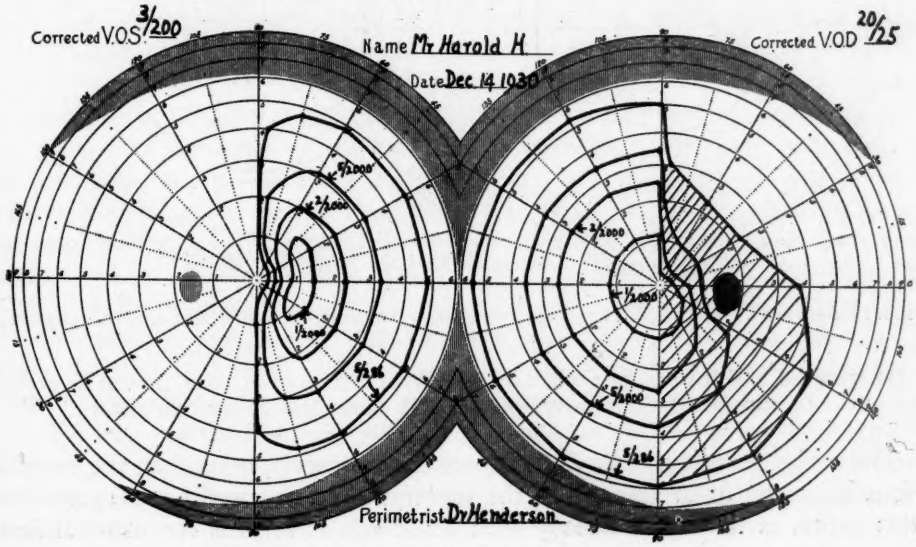


FIG. 644.—*Case* 30. The fields of vision on admission.

Eleven years previously, i.e., when he was 13 years of age, his growth became extremely rapid for a period of about six months, after which it continued to be excessive, although less markedly so, until two years before admission, when it ceased. He had not observed any change in his features, but the hands had become heavy and puffy during the last few years. There was no asthenia.

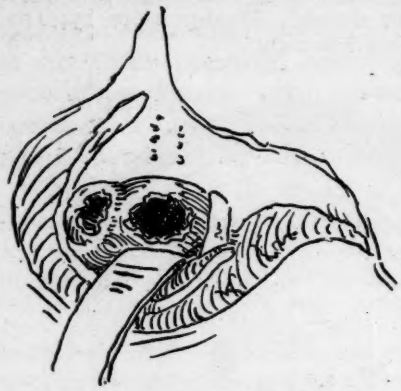


FIG. 645.—*Case* 30. Operator's sketch to show the opening in the capsule through which the acidophil tumour was excavated by suction. Note the extrasellar extrusion of the adenoma surrounding and concealing the left optic nerve accounting for the marked asymmetry of the visual fields (cf. *Fig.* 644).

For two years there had been a progressive failure of vision in the left eye and it had been nearly blind for nine months. He had observed a progressive constriction of the right temporal field for the past three months. There had been occasional left frontal headache for one year.

Examination showed a typical acromegalic giant, though the traces of acromegaly were inconspicuous. Height 6 ft. 6 in. Weight 198 lb. (14 st. 2 lb.). There was bitemporal hemianopia (*Fig.* 644), V.O.S. 3/200 and V.O.D. 20/25, pallor of the optic disks especially in the left eye, and an enlarged sella (25 × 18 mm.).

On *Dec.* 19, 1930, a right transfrontal exploration was made, and a soft tumour containing a small hæmorrhagic cyst was excavated by suction. A localized extrusion of the tumour, which had penetrated the diaphragma and overlay the left optic nerve, was also removed (*Fig.* 645). This was followed by a remarkable and almost complete recovery of vision before his discharge three weeks later (*Fig.* 646).

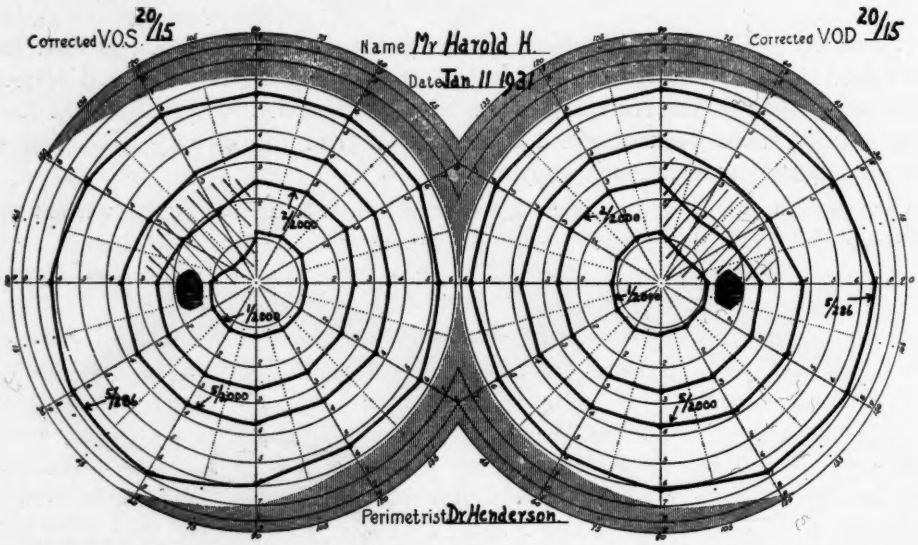


FIG. 646.—*Case* 30. The fields of vision three weeks after the radical excavation of an acidophil adenoma by the transfrontal route.

He returned to full work, and when he last wrote in *December*, 1937, he was in excellent health and had remained free from symptoms. He never had X-ray treatment.

The multitude of systemic disturbances in acromegaly, other than the externally obvious gigantism or overgrowth of the superficial tissues, need not be enumerated in this paper, as they have already been described, as regards the material in the

Clinic, by Davidoff (1926),[13] who analysed the symptomatology in 100 cases. Attention may be drawn, however, to the great variation in the severity and importance of the symptoms in different cases, and to the fact that the less noticeable effects of the excessive growth-hormone secretion on the internal organs are often the most serious in the long run. It is the headaches and other subjective troubles rather than the changed external appearances which commonly make an acromegalic's life so miserable, as was emphasized by Leonard Mark. The severity of the disease and the results of treatment have to be assessed, therefore, largely from these subjective complaints.

It is also important to bear in mind when evaluating the early and late results of treatment that acromegaly is rarely a steadily progressive disorder, and is in many cases a self-limiting disease. The clinical course is frequently characterized by waves of increased secretory activity, which are commonly referred to as periods of 'acromegalism', with pronounced and sometimes prolonged remissions; and in many cases the disease eventually reaches a permanently inactive stage. Some patients, as Cushing (1927)[8] has put it, are intermittently or even continually miserable from headaches or the toxic effects of the disease; some with pronounced acromegaly go through a long life little troubled by these symptoms; and still others may never have more than a single primary wave of transient hyperpituitarism. It is necessary to be cautious, therefore, in attributing improvement, especially in the constitutional symptoms and headaches, to treatment which was given during a phase of increased activity. Visual impairment, when it is present, may also show considerable improvement during the spontaneous remissions.

Cessation of clinical signs of progress is probably associated with spontaneous arrest in the growth of the tumour. Sometimes, however, the tumour continues to expand and forms a mass of relatively agranular cells (the 'mixed' adenoma of Dott and Bailey[14]) which eventually produces visual disturbances; and the signs of active acromegalism may even become replaced by those of hypopituitarism.

Acromegaly, broadly speaking, is associated with three main groups of symptoms—namely, (*a*) the various systemic disturbances, (*b*) headaches, and (*c*) impairment of vision. In some patients loss of vision, which may be very marked, is the only serious symptom. In others there is no disturbance of vision, and the chief complaint may be of severe and prostrating headaches or of some effect of the secretion on the internal organs of the body. The majority of patients, however, show all of these manifestations combined in varying degrees.

It is more difficult to evaluate satisfactorily the results of treatment when patients complain of such a variety of symptoms each one of which must be separately considered, than it is in patients with chromophobe adenomata in whom the principal manifestations are due to the local pressure effects of the enlarging tumour. The 61 patients who survived operation have been divided, according to the relative importance of their symptoms, into three groups for the purpose of showing the results of surgical treatment. The chief symptoms in each were: (1) Severe loss of vision—12 cases; (2) Severe headache—13 cases; (3) Visual impairment, headache, and active acromegalism—36 cases.

The late survival results will be referred to briefly along with the early results; the distinction between them is less easily defined than in cases of chromophobe adenoma because of the tendency to spontaneous remissions and transitory exacerbations.

1. Severe Loss of Vision.—This was the chief complaint and the only indication for operation in this group of 12 cases. Headache was a negligible symptom, as only 5 of the patients had experienced slight headaches, usually transient, at the onset of the visual trouble. The patients all showed the typical features of outspoken acromegaly, with vision reduced to 20/200 or less in the more seriously affected eye (in 8 instances there was bare light perception or blindness), and in most of them there was also considerable impairment in the better eye. The sella was enlarged in all instances, and usually markedly so. The tumours were therefore large and relatively inactive and approximated to 'mixed' adenomata. All except one were operated on by the transsphenoidal route.

The operative results were highly gratifying in this group (e.g., *Cases* 29 and 30). In 4 patients normal vision was restored to both eyes, and in 7 others there was marked improvement. The visual recovery was usually observed soon after operation, but it sometimes took a year or two to reach the maximum. It is noteworthy that in two patients vision in the worse eye recovered from mere light perception to 20/20 and 20/40 respectively. In another patient (P.B.B.H. Surg. No. 29859) one eye which had been affected for five years and was known to have been blind for two and a half months, had recovered to 20/200 when examined six months after operation; this improved to 20/30 three years later, and when the patient was examined at New Haven in *November*, 1937, ten years after operation, the acuity was 20/25 with a full visual field.

The late results are equally gratifying, for 10 of the 12 patients have enjoyed a normal life up to the present time, from seven to twenty-four years after operation, without any recurrence of headache, acromegalism, or visual failure; and another patient has had a secondary operation for recurrence of visual failure, due to a cystic extension in the temporal lobe, in another clinic with a good and enduring result. In 8 cases the operation was more than fifteen years ago.

As regards radiation, there is no evidence that it had any beneficial effect, for although 3 patients in the later years of the series had post-operative X-ray therapy and 2 others had radium treatment, it was not given to those with the longest survivals.

2. Severe Headache.—In contrast to the last group of 12 patients there were 13 others, all with normal or almost normal vision, in whom severe and intolerable headache was the chief indication for operation. Some of them also showed well-marked symptoms of 'active acromegalism', of which asthenia and hyperidrosis were usually the outstanding features. The sella was either normal or only very slightly enlarged; it was never widely expanded.

The results of operation in these cases varied greatly. The headache promptly disappeared after operation in only 2 cases. In 6 instances it gradually decreased in severity within the next few months and eventually disappeared. In the remaining 5 cases operation had no effect on the severity of the headache, which long continued to be a most distressing symptom. Three of the latter cases, although without any relief during the first three years, were according to later reports free from headache after intervals of from five to ten years following operation; the other two died from the effects of the tumour after two and a half and ten and three-quarter years respectively, without obtaining any relief from the almost continuous headache.

The late results were less good than in the group of 12 patients with marked loss of vision, for 6 of the 13 patients have since died; in 5 of them death was due to the systemic effects of the adenoma. The remaining 7 patients are alive and well from three and a quarter to twenty-three years after operation.

Attempts were made in 7 of these patients to alleviate the headaches by means of radium or X-ray therapy. In some, it had been given a year or two before operation, and in others from six to twelve months after operation. The results were variable; they were never dramatic, nor were they conspicuously different from the results of operation alone. In some cases the headache was relieved by the radiation, but in others it remained unaffected. These few cases do not, however, give a true indication of the effect of the X-ray therapy, for severe headache was ameliorated by X-ray therapy alone in cases not surgically verified and therefore excluded from this study. It is believed that X-ray therapy should always be tried first when headache is the predominant symptom; if it fails, operation is not likely to be successful.

It is not known why acromegalic headaches are sometimes so severe and so intractable to all forms of treatment, while the headache associated with chromophobe adenomata rarely if ever attains such extreme severity and almost invariably disappears after operation. The headache of most pituitary adenomata is presumably ascribable to increased tension within the sella, but it is evident that other factors may be involved in acromegaly. Some acromegalic patients never experience headache even though the sella is widely expanded (*Group* 1), and again others complain only of intolerable headache despite the fact that the pituitary gland is not demonstrably enlarged (*Group* 2).

Furthermore, headaches sometimes continue unabated after decompression of the sella. It may be noted, for example, that there was no involvement of the chiasma, no bulging of the diaphragma sellæ, and no apparent increase of intrasellar tension in two patients who submitted to secondary transfrontal operations, in the hope of obtaining some relief from the cephalalgia which had persisted after transsphenoidal operations; the sella was normal in size in both cases, and an opening made through the diaphragma failed to give any relief. Intracranial tension is not increased and is not a factor in the causation of these headaches; futile subtemporal decompressions have been made on several occasions without giving relief.

It has been suggested that the headaches of acromegaly are due to the participation of the sella in the general osseous overgrowth, so that its walls give way less easily than do those which enclose a chromophobe adenoma. It is more likely, however, that the chief factor is some general systemic effect of the secretion on all the bones of the skull or on the meninges. These headaches are rarely localized to the frontal or temporal regions as in cases of chromophobe tumour, but are more often generalized throughout the head and are frequently described as 'head pains'. They are usually more severe during the periods of increased secretory activity. Their gradual disappearance after an interval of several years cannot, of course, be attributed to the operation; it is probably associated with a spontaneous regression in the activity of the disease.

3. Visual Impairment, Headache, and Acromegalism.—In about half of the 36 cases in this final and larger group, visual failure was as advanced as in the 12 patients of Group 1, while in the remainder vision was scarcely affected.

All the patients suffered from headaches, and in about half of them it was the outstanding complaint. In some instances the other manifestations of secretory activity were very pronounced. There was considerable variation in the size of the sella in this group.

Operation was followed by improvement in vision, the recovery of which was usually complete, in all except 3 patients in whom the defect was far advanced. The headache was immediately relieved in 19 cases; in 12 it was only partially relieved and continued to be a source of complaint for some time, although it gradually disappeared within a few months or a year or two. In only 5 instances did cephalalgia continue unabated for years after operation, as in some of the patients in Group 2.

Supplementary radiation was given in 17 cases, either before or after operation, but it had no noticeable influence on the results.

From a consideration of the foregoing analysis it appears that loss of vision responds to operation better than any other symptom. The visual recovery is consistently good in all except the most advanced cases, and is, on the whole, even better than that obtained in cases of chromophobe adenoma. Recurrence of visual failure is uncommon.

The relief of headache, on the other hand, is most uncertain. Operation apparently has least effect in those cases in which the headache is apt to be most persistent and severe, namely, in cases with an unexpanded sella and normal vision. When the tumour is large, with an expanded sella and marked visual disturbances, headache is rarely severe, and it is often completely relieved, as in cases of chromophobe adenoma. The tendency for even the most persistent headaches to disappear in course of time can only be ascribed to a spontaneous amelioration of the disease.

While operation usually gives a favourable end-result as regards the local symptoms, it has to be remembered that the size of the tumour is no indication of the severity of the systemic disturbances, and that the possibility of reducing the secretory activity of the adenoma often has to be considered. The question is sometimes asked, now that the mortality rate has reached a sufficiently low level, whether an acidophil adenoma should be attacked while it is still small in the hope of preventing its further growth and of forestalling possible future devastating effects on the body.

During the early years of pituitary surgery, patients with acromegaly were treated on much the same lines as those with chromophobe tumours, i.e., with the sole object of relieving defective vision and other local pressure symptoms. It was observed, however, that when the hyperpituitarism was marked, operation was sometimes followed by an unexpected improvement in the acromegalism itself, and that the progressive malady was apparently checked.

Cushing (1927)[8] has expressed the opinion, from his experience with a few patients having small acidophil adenomata without local pressure symptoms, that it is possible to influence favourably the secondary effects of hyperpituitarism by removing some of the adenomatous tissue. The benefit derived from the operation in such cases may be estimated by: (*a*) The subjective improvement experienced by the patient, e.g., increased strength; (*b*) The visible diminution of acromegalism, e.g., decrease in the swelling and puffiness of the soft tissues so

that the skin becomes more loose and wrinkled; and (*c*) Some measurable gauge of the patient's improvement, such as loss of weight from shrinkage of the œdematous tissues, a lowering of the basal metabolic rate, often high in acromegaly, and an increased carbohydrate tolerance as indicated by blood-sugar examinations.

In discussing this problem, Cushing cited three illustrative cases, all of which had been operated on during the preceding twelve months. It may be of interest, therefore, to record briefly the present status of these patients, after an interval of ten years. The first patient (P.B.B.H. Surg. No. 26204), a woman, remained free from headaches, showed no further advance in her acromegaly and symptoms of hyperpituitarism, and on her last report in May, 1937, was in excellent health. The second patient (P.B.B.H. Surg. No. 27770), a dentist, had a temporary return of headaches a few years after operation, although they were much less severe than formerly, and he was active and well when he last wrote in October, 1936. The third case (P.B.B.H. Surg. No. 25410) was also well when she reported in October, 1936. One must therefore conclude that a permanent amelioration in the systemic symptoms of acromegaly can be obtained by operation.

As regards X-ray therapy there seems to be little doubt from general experience that acidophil adenomata respond better than the chromophobe variety, and that in a proportion of cases the symptoms can be relieved and the course of the disease checked by radiation alone. The present series is not sufficiently large to show statistically the effect of supplementary X-ray therapy as was done in the chromophobe series. All that can be said is that in some cases the symptoms without doubt were favourably influenced by X-ray therapy, and in others no noticeable improvement in the results that could be ascribed to the radiation was observed. Other patients with acromegaly, not included in this series, were successfully treated in the clinic by X-ray therapy alone (Vaughan, 1938)[27].

The conclusion is that symptoms which depend on hypersecretion rather than on the size of the tumour should in the first instance be treated by X-ray therapy. Chiasmal compression, on the other hand, should be relieved immediately by operation, with radical excavation of the tumour, which otherwise is prone to extend far beyond the sella and produce an asymptomatic intracerebral extension (cf. *Fig.* 599); operation should, of course, always be followed by X-ray therapy. As regards the surgical approach, the transsphenoidal operation has given satisfactory results and is possibly to be preferred.

C. THE LATE RESULTS OF OPERATION

In acromegaly, the mixture of constitutional and local symptoms, either of which may dominate the clinical picture, and the tendency for them to show exacerbations and remissions, make it difficult to compare the late results on the same rigid basis that was adopted for the chromophobe adenomata, namely, of considering only the interval before the reappearance of progressive visual failure (or other local pressure effects), quite apart from how much longer it may have been before the loss of vision became serious. Vision may be restored to an acromegalic and his headaches permanently relieved, and yet certain systemic effects may continue to progress. In some cases there are intermittent waves of acromegalism which are quite transient but very distressing while they last. In others, the adenoma produces over a period of years, deleterious, though barely noticeable, changes, which may eventually be responsible for the patient's premature

death, without any definite recurrence of headaches, visual failure, or other outstanding symptoms; the most serious effects are those on the cardiovascular system and on sugar metabolism. For these reasons, when discussing the late results of acromegaly, it is more instructive to give the survival statistics than to dwell upon the recurrence rates, particularly as the post-operative history of most of the patients is now sufficiently long to give a fair idea of the end-results.

The follow-up figures for the 61 patients who were discharged from hospital are summarized in *Table XIV*. The present state of all the patients is known with the exception of 4 patients who after reporting for periods varying from two and a half to eight years following operation, have failed to do so recently; in 2 of them the follow-up period was less than five years. The follow-up statistics at the five-years interval are, therefore, complete for 59 of the 61 patients.

Table XIV.—Acidophil Adenomata: Summary of Follow-up of the 61 Patients who were Discharged from Hospital

	Number of Cases	
Alive and well (from two and a half to twenty-four years after operation)	30	
Alive and well (after secondary operation for recurrence of symptoms)	1	
Alive with recurrence of symptoms (untreated)	2	
	—	33
Dead from symptomatic recurrence of tumour (including 3 patients in whom the exact cause of death is unknown)	23	
Dead from incidental cause—no recurrence of symptoms ..	5	
	—	28
Untraced		0
Total ..		61

The number of patients who were known to be alive at intervals of 5, 10, 15, and 20 years after operation, and also of those who had remained free from definite symptoms of recurrence at the same intervals are shown in *Table XV*. These figures are considerably better than those for the chromophobe adenomata (cf. *Table XI*), as would be expected from the tendency of acidophil adenomata to undergo spontaneous remission, possibly with cessation of progress in the disorder.

Table XV.—Acidophil Adenomata: Number of Patients known to be: (1) Alive; and (2) Free from Recurrence of Symptoms at Intervals after Operation

Interval after Operation	Maximum Number of Patients	(1) Number of Patients known to be Alive	(2) Number of Patients known to be Free from Recurrence of Symptoms
5 years	61	48 (78·7 per cent)	43 (70·5 per cent)
10 years	51	33 (64·7 per cent)	27 (53·0 per cent)
15 years	32	16 (50·0 per cent)	13 (40·6 per cent)
20 years	21	8 (38·1 per cent)	8 (38·1 per cent)

It may be of interest to point out that Dr. Cushing's first operation on a case of acromegaly (1909)[4] was performed on *March* 25, 1909, at the Johns Hopkins

Hospital. The patient continued to be self-supporting as a farmer in the Middle West for the next twenty-one years, when his sudden death was reported at the age of 59. He was well and active to the end, and was in fact harvesting a few minutes before he died.

Dr. Eisenhardt (1935),[16] in a paper concerning long post-operative survivals in cases of brain tumour, referred to two patients with pituitary adenomata, one chromophobe and the other acidophil, who were still alive twenty-four and twenty-three years and nine months respectively after operation in the Johns Hopkins Hospital before the commencement of this series.

It may not be amiss, before enumerating the causes of death in the present series, to illustrate the variety of factors concerned in the late results by quoting briefly from the detailed report by Cushing and Davidoff (1927)[12] on the pathological findings in four autopsied cases of acromegaly. The causes of death in their four cases were: Case 1, Progressive lethargy and weakness associated with widespread arteriosclerosis. There had been very severe headaches but no visual disturbances, and the adenoma was very small; the pituitary body was almost normal in size. Case 2, The local effects on the brain of a huge intracranial extension of the adenoma which had caused blindness from primary atrophy. Case 3, Cardiac incompetence leading to chronic passive congestion and anasarca. A huge, actively secreting extension in the temporal lobe (*Fig.* 599) had never produced visual disturbances or headaches, and was in fact entirely unsuspected. Case 4, Diabetic coma; the pituitary body was slightly enlarged, but had not implicated the chiasma.

Cushing and Davidoff refer to a list of 44 autopsied cases in the literature and comment on the fact that diabetic coma was the most frequently recognized cause of death (11 cases), with cardiac failure next in frequency (7 cases).

In the present series the chief causes of death in the 23 patients who succumbed to the effects of the tumour were: (1) Diabetes mellitus, 6 cases; (2) Acute myocardial failure, 4 cases; (3) Hypertension and apoplexy, 3 cases; (4) Intracranial extension, 7 cases; (5) Exact cause unknown, 3 cases. Thus in acromegaly death is more often due to the secondary constitutional effects on other organs than to the local intracranial effects of the tumour, whereas in cases of chromophobe adenoma it is almost always due to the effects of an extension into the brain.

Glycosuria, like the other constitutional effects, is very irregular in occurrence and in time of onset; it may appear early or late in the course of the disease, and may be discovered during the investigation of symptoms suggestive of diabetes or accidentally during routine examination. It is a common finding; in the series of 100 cases one out of four had shown glycosuria and approximately one out of eight had clinically outspoken diabetes mellitus. Acromegalic glycosuria is characterized in most cases by marked variations in intensity from time to time, so that it is hardly possible to estimate its severity from a short period of observation. In some cases[13] it disappears spontaneously and permanently, in others there are transient waves of glycosuria, any one of which may terminate rapidly in coma, and, indeed, those who died in coma before the days of insulin, often did so after a very brief illness. The milder forms of acromegalic diabetes can be kept under control by dietary restrictions alone. In the more severe cases the glycosuria can be held in check by insulin, which, however, is not so effective as in diabetes mellitus of pancreatic origin, owing to the excessive production of the anti-insulin factor by the acidophil adenoma.

Any complication of hyperglycæmia may have serious and even fatal results. In one instance, for example, death was precipitated by the development of gangrene in the foot. Another important, though not fatal, complication is diabetic retinitis; 2 patients became practically blind from this retinal complication several years after successful operations, without any other sign of secretory activity in the interval.

The anterior lobe of the pituitary gland has an important and possibly a controlling influence over most of the endocrine organs; but whether this influence is exercised through the medium of several separable hormonal factors, or by only one or two active substances, the different effects of which are determined by the organ acted upon, is still debatable. There is, however, little doubt that the constitutional disturbances in acromegaly are due to the over-production of normal secretion by the acidophil cells in the adenoma and not to the elaboration of an abnormal substance.

It is of interest to recall that the experimental acromegaly which Putnam, Benedict, and Teel (1929),[20] working in Cushing's laboratory, produced in dogs by the injection of an anterior-lobe extract showed all the manifestations of acromegaly as it occurs spontaneously in man. The secretion in acromegaly apparently comes from one type of cell, but it has many effects which may occur simultaneously or quite independently; the effects on the internal organs may be grouped under two headings—namely, the endocrine disturbances and splanchnomegaly.

As regards the endocrine disturbances, the anti-insulin effect is the most important, and is the only one which is likely to have serious consequences. The functional significance of the morphological changes which are commonly present in the other endocrine organs, especially the thyroid gland and the suprarenals, are not clearly understood; they do not, however, appear to have any deleterious effects. The loss of sexual function, in the writer's opinion, is a deprivation syndrome due to compression of the normal anterior-lobe cells by the enlarging tumour, and is not due to the activity of its secretion.[17]

The tissue overgrowth affects not only the skeleton and superficial soft tissues, producing the outwardly visible acral changes, but also most of the internal organs, and it is in reference to the latter that the term splanchnomegaly is applied. The cardiovascular changes are by far the most important of these effects.

The cardiovascular changes associated with acromegaly are sometimes out of all proportion to the splanchnomegaly of other organs, and it is probable that in such cases they are due to a secondary and more specific effect, possibly through the suprarenals. The heart may be enormously enlarged, even as much as three times its normal weight. In some of these cases it is associated with, and is no doubt largely secondary to, marked peripheral arteriosclerosis; the blood-pressure is very high, and it is not surprising to find that acromegalics sometimes die unexpectedly in middle age from apoplexy with hemiplegia, as happened to 3 of the patients from eleven to seventeen years after successful operations.

That apoplexy in these seemingly healthy patients occurred prematurely as a result of a high blood-pressure is suggested by the following story: A woman (P.B.B.H. Surg. No. 50) of 30 years, who complained of severe headaches and symptoms of acromegalism, especially sweating, had a transsphenoidal operation *April*, 1913. A solid tumour was partially removed and the symptoms were

relieved. She remained well for thirteen years and then began to have spells of dizziness, and she was re-admitted in *April*, 1926, for investigation. There had been no headache or visual disturbance since operation, but there was evidence of slowly progressive cardiovascular changes. The systolic blood-pressure was 210 mm. There was no glycosuria. She had several courses of X-ray treatment during the next few months with considerable improvement, and the blood-pressure fell about 60 points during the next year, after which it began to rise again. She remained quite well until her sudden death from apoplexy at 47 years of age, in *January*, 1931, i.e., seventeen years and nine months after operation. The hypertension and apoplexy in this case must be attributed to the effects of continuous or intermittent secretion from the residual acidophil adenoma.

Other cases have shown an enormously enlarged heart, but no evidence of arteriosclerosis, and death has occurred from valvular incompetence and cardiac failure. There were 4 patients who died unexpectedly and suddenly, without hemiplegia, a few years after a successful operation, and during that time they had been comparatively well. It is quite reasonable to suppose, as had been suggested by the attending physicians, that death was due to the sudden failure of a weak, even though hypertrophied, heart.

The local effects of intracranial extension are less common causes of death in acromegaly than they are in cases of chromophobe adenoma. The local symptoms of recurrence appeared within five years of operation, and death usually occurred within another year or two. The commonest symptoms before death were epileptic attacks, occasionally with olfactory hallucinations, and convulsions, and in some, but not all, cases there was advancing visual failure. Mental deterioration was not so common in the terminal stages as in cases of chromophobe adenoma.

IV. THE ADENOCARCINOMATA

These rare tumours, of which there are 11 examples in the series, represent only about 3 per cent of pituitary tumours.* Their pathology has not been thoroughly studied, and little is known, as yet, about their clinical behaviour. In view of the rarity of these cases, the surgical results will be described with brevity.

The adenocarcinomata are composed of non-granular cells. The suggestion that the chromophobe elements are more likely to undergo malignant transformation than the more highly specialized acidophil or basophil cells, fits in with the clinical history in most of the cases in this series, although in one instance there had been a wave of acromegalism previously. In a few cases the tumour had a more rapid clinical course and seemed to be invasive from the outset.

Histologically, the tumour cells, which show a striking variation in shape and size, are sometimes arranged in alveolar formations, while in other parts they are in closely packed masses. Mitoses are frequent.

These adenocarcinomata tend to invade surrounding structures, especially the dura and the bone of the cranial base. Occasionally the tumour extends in the form of a flat warty growth along the dural planes over the floor of the middle fossa and backwards into the posterior fossa. In others its gross appearance

* According to figures supplied to Dr. Cushing some years ago from the Mayo Clinic, this was about the same percentage of malignancy that they had observed in their many thousand cases of thyroid adenomata.

resembles that of a chromophobe adenoma. These tumours rarely metastasize; in one of the cases in this series, however, autopsy revealed metastases to the liver, which were identical in structure with that of the pituitary tumour. The malignant character of the growth is possibly reflected in the fact that only 1 of the 11 patients is still alive.

As regards operative mortality, there were 11 operations (4 transsphenoidal, 4 transfrontal, and 3 temporal explorations) with no deaths.

Clinical Varieties.—Clinically, most of the cases fall into two well-defined groups (Groups 1 and 2) which show striking differences in symptomatology, in the gross appearance of the tumour, and in the surgical results. The early and late results will be briefly described for each group separately.

Group 1.—In 6 cases the clinical history, the clinical findings, and the naked-eye appearance and consistency of the tumour at operation were indistinguishable from those observed in cases of chromophobe adenoma. One patient, however, showed the unmistakable features of former acromegalism, which he had noticed himself four years previously. Loss of vision, which was usually marked (it was reduced to 20/100 or less in the more seriously affected eye in every case), was the only serious symptom, and was the only indication for operation. The other cranial nerves were not involved in this group. Operation was followed in every case by marked improvement in vision; the early and late results were, on the whole, similar to those in cases of chromophobe adenoma. In 3 cases symptoms recurred and death ensued from the effects of the tumour within two years of operation. The other 3 cases, however, all of whom had several courses of post-operative X-ray therapy, lived for a number of years without recurrence of symptoms; 2 died six years later at an advanced age from cerebral thrombosis and pneumonia respectively, and the third case died seven and a half years after operation from pneumococcal meningitis, eighteen months after the last of several radium treatments. It is tempting to assume that the first 3 cases might have lived for a longer time if they had received post-operative X-ray therapy.

Group 2.—There were, on the other hand, 3 patients with a symptomatology totally different from that characterizing the previous group. Their outstanding manifestations were trigeminal involvement and ocular palsies; 2 of them also had monocular blindness. In contrast to the cases in Group 1, nothing of value was accomplished by the operation, the symptoms steadily progressed, additional cranial nerve palsies appeared, and death ensued after intervals of 4, 6, and 21 months respectively. Post-operative X-ray therapy was given in one case without any apparent benefit. Trigeminal pain was the first and outstanding symptom in 2 cases, and operation for section of the sensory root in the middle fossa proved to be extremely difficult as the infiltrating tumour had surrounded the ganglion.

In contrast to the previous group, the tumours were of dense consistency. The operative findings, and in 2 cases the post-mortem examination, showed that the tumours had infiltrated through the cavernous sinus. Thence they passed outwards over the middle fossa in the form of a hard flat mass between dura and bone, backwards into the posterior fossa and downwards in front of the brain-stem as far as the foramen magnum. They had extended extracranially through the foramen ovale and other foraminæ in the cranial base, as well as through the bone into the air sinuses. All 3 cases eventually showed involvement of the facial and acoustic nerves. The final clinical picture was, therefore, a combination

of the syndromes of the middle fossa and the cerebello-pontine angle. The chief disability experienced by the patients was due to the posterior fossa extension. Two cases showed, clinically, a complete series of marked cranial nerve palsies, from the optic to the hypoglossal inclusive, on one side.

There is, therefore, a striking clinical similarity between the adenocarcinomata in Group 2 and cases of nasopharyngeal carcinoma or of malignant endothelioma. On the other hand, they differ markedly from those chromophobe adenomata which erode through the basisphenoid and project into the nasopharynx, for the latter do not infiltrate widely along the bone to produce distant cranial nerve palsies.

In their symptom-complex the remaining 2 cases showed a combination of features belonging to both groups. One of them clinically resembled the cases in Group 1, with commencing trigeminal involvement in addition. In the other case a large mass of tumour infiltrated extradurally across the middle fossa to the pterion, eroded the squamous portion of the temporal lobe, and appeared as a soft bulging swelling externally, underneath the temporal muscle. The patient had unilateral blindness and proptosis, and radiography showed destruction of the greater wing of the sphenoid. She nevertheless, after a radical removal of the tumour, is still alive seventeen years later.

Clinically, it is clear that these 11 cases which have been pathologically classified as adenocarcinoma belong to two distinct groups. The few examples which, from their behaviour, may be regarded as true adenocarcinomata represent only about 1 per cent of all pituitary tumours; they appear to be hopelessly malignant. The larger group apparently responded to treatment almost as well as the chromophobe adenomata and in all probability were such despite the contemporary histopathological diagnosis.

Whether a more critical review of the cases will reveal a histological distinction corresponding to the differences in clinical and pathological behaviour, must, for the present, remain unanswered. The tumours deserve further study.

V. CONCLUSION

It is a very great pleasure to acknowledge my gratitude to Dr. Harvey Cushing for allowing me to review the surgical results in this remarkable series of pituitary tumours. His early work gave the initial stimulus to the surgery of the pituitary and, in no small measure, to endocrinology itself. This late evaluation, however imperfect it may be, helps to complete the story of the pituitary as he has seen it. I have described the results without any attempt to appraise them, for their excellence makes this unnecessary. Nor is it possible to make comparison between the work of my former teacher and that of other surgeons, for no comparable series has yet been published.

This report, as I stated in the Introduction, could not have been undertaken without the collaboration of Dr. Louise Eisenhardt, and I should like to pay a tribute to her work as Curator of the Brain Tumour Registry in New Haven, which was founded with the records of Dr. Cushing's collection of intracranial tumours. It is a great achievement to have such complete follow-up details of patients who are scattered all over the American continent and in other parts of the world.

I also wish to acknowledge the help of others too numerous to mention individually, especially the many neurological surgeons, physicians, and general

practitioners who willingly re-examined patients for the purpose of this follow-up; all of Dr. Cushing's former assistants whose full case histories and careful visual field studies made it easy for me to collect the necessary data; to Dr. Brodie at New Haven for helping me in 1936 to re-examine so many of my one-time patients; and, finally, the patients themselves, for their eagerness to show their gratitude to Dr. Cushing by keeping him informed of their progress and even travelling long distances for a further and often tedious examination.

I am indebted to the Board of the National Hospital, Queen Square, for granting me three months' leave of absence to enable me to make this study at first hand in the Autumn of 1936. The beginnings of this work were made possible by the tenure of a Rockefeller Fellowship from the Medical Research Council.

VI. SUMMARY

1. A report has been made of the surgical results of Dr. Harvey Cushing's Brigham Hospital series of histologically verified pituitary tumours. The series covers a period of twenty years, from 1913 to 1932, and includes 338 cases. The report deals principally with surgical mortality statistics, the early results of operation, and a follow-up study of the patients, the last of whom was operated upon on July 23, 1932. Only 3 of the 338 patients have not been heard from since their discharge from hospital. There are 260 chromophobe adenomata (including 32 'mixed' adenomata), 67 acidophil adenomata, and 11 adenocarcinomata. No example of a basophil adenoma had been identified. The incidence of pituitary adenomata in Cushing's series of 2,023 verified intracranial tumours is 17·8 per cent.

2. Pathology. Chromophobe adenomata produce only local compression effects, whereas acidophil adenomata evoke general constitutional disturbances and often local effects in addition. The adenocarcinomata are apt to infiltrate surrounding structures. Reference is made to the surgical importance of the various extrasellar extensions.

3. The operative procedures are referred to briefly, especially the more radical excavation of the intrasellar tumour and the immediate liberation of the chiasma by the transfrontal operation; also the importance of ventriculography in selected cases with intracranial extensions and the use of lateral flaps for the removal of extensions which are shown by ventriculography to be accessible.

[Paragraphs 4 to 17 refer solely to the chromophobe adenomata, of which 28 case reports have been chosen to illustrate the various features of these tumours and their surgical results.]

4. The operative mortality rate was 5·3 per cent for transsphenoidal operations and 4·5 per cent for intracranial operations. The combined figures show 15 fatalities after 304 primary or secondary operations, i.e., 4·9 per cent; this was reduced to 2·4 per cent during the last ten years of the period. About half the fatalities after each operation were due to the effects of a large intracranial extension; the remainder were due to meningitis (2·3 per cent) after transsphenoidal operations and to blood-clot formation (2·2 per cent) after transfrontal operations.

5. The early results, based on the patients' condition six months after operation, show that 65 per cent of the total number before operation returned to their normal work; there was no essential difference between the operations,

though visual recovery was usually more complete after the transfrontal procedure. In 29 per cent there was no improvement and in 5·4 per cent of the cases symptoms had progressed in less than six months. The results were disappointing in cases with homonymous hemianopia or unilateral blindness.

6. Homonymous hemianopia was present in 10 per cent of cases. There are two clinical types, depending on whether the optic tract or the optic radiation has been chiefly involved. The transfrontal operation produced poor results. The transsphenoidal operation is preferable when the optic tract is compressed because the chiasma is usually prefixed, whereas a large extension into the temporal lobe should be approached directly through a lateral flap.

7. Unilateral blindness. The disappointing results in these patients, many of whom had a large intracerebral extension, show the importance of early exploration for obscure unilateral failure of vision, because once the eye has become blind there may be no further increase in symptoms until signs of an inoperable extension occur.

8. Central scotomata or inferior quadrantal defects are typical, but uncommon. They are supposedly due to a similar mechanism, i.e., upward displacement of the optic nerve against the anterior cerebral artery or the margin of the optic foramen when the defect is unilateral; and elevation of a prefixed chiasma by a retrochiasmal tumour when the defect is bilateral.

9. Blindness. The chances of visual recovery in a totally blind eye are discussed; vision may return in an eye that has been blind for as long as three months, and when light perception is still present the restoration may be complete.

10. The late results, analysed on the basis of the duration of improvement after operation, indicate great variability in the rate of growth and behaviour of the tumours. After a successful transsphenoidal operation without irradiation some patients had no further trouble for as long as twenty years. On the other hand, a rapid recurrence within two or three years may take place even after a far more radical transfrontal operation plus X-ray treatment. While many patients maintained this improved status for ten to twenty years, 95 per cent of those who had a recurrence showed indications of it within five years after operation.

11. X-ray therapy. No patients were given X-ray therapy alone, but many received it after operation. The beneficial effect of post-operative X-ray therapy and the superiority of the transfrontal over the transsphenoidal operation as regards the late results are shown by an analysis of 187 well-controlled cases. Only 32·8 per cent of patients after a transsphenoidal operation alone failed to show evidence of symptomatic recurrence at the end of five years; this was increased to 65·3 per cent for those who had X-ray therapy in addition. Of the patients who had a transfrontal operation alone, 57·5 per cent remained free from recurrence at the end of five years, and this was increased to 87·1 per cent for those who had transfrontal operation plus X-ray therapy.

12. Radium implantation by the transsphenoidal route was tried in a few cases, but quickly abandoned because of the great danger of necrosis of bone and eventual meningitis.

13. Recurrences. There were 44 secondary operations for recurrence of symptoms. The results in all respects were as good as those following primary operations. All recurrent cases should have a secondary operation without delay.

14. Cysts. About 17 per cent of adenomata prove to be cystic; they cannot be clinically distinguished from solid tumours. The fluid may be hæmorrhagic

or xanthochromic, and the cyst may be intrasellar or intracerebral. Cysts should be treated in the same manner as solid tumours, i.e., by transfrontal operation plus X-ray therapy. They are apt to refill rapidly after evacuation and to be associated with post-operative clots if portions of the wall have been removed for histological verification.

15. Post-operative clot formation occurred in 14 per cent of patients who had transfrontal operations and is consequently the most serious objection to that procedure. It was the cause of 3 fatalities owing to the tardiness of its recognition. Two varieties are distinguished: (1) Extradural; (2) Suprasellar. Neither is necessarily fatal, but a suprasellar clot is more difficult to remove and is likely to add further injury to the already damaged nerves.

16. Nasopharyngeal extensions are uncommon and should be treated by X-ray therapy with or without transfrontal excavation to relieve chiasmal compression; the nasopharyngeal mass should not be disturbed.

17. The effects of intracranial extensions have been defined according to their situation. The ultimate prognosis in untreated cases has been discussed.

[Paragraph 18 refers solely to the acidophil adenomata of acromegaly and paragraph 19 to the adenocarcinomata.]

18. The acidophil adenomata. The clinical course of acromegaly differs from that of the chromophobe adenomata in several respects which make it difficult to assess the early and late results of treatment on a similar basis. The two types of symptoms—local pressure (visual) effects and systemic effects—frequently show spontaneous remissions and exacerbations, and often respond differently to treatment. Operation usually produces marked improvement in vision, but may have no effect on the severe headaches, especially in cases with a small tumour. The systemic disturbances are ultimately apt to be the most serious because of the deleterious effects of the hormonal secretion on the cardiovascular system and on sugar metabolism. The operation mortality rate is slightly higher than for the chromophobe adenomata, but the late surgical results appear to be better. The acidophil tumours are more amenable to X-ray therapy.

19. The adenocarcinomata have not yet been subjected to sufficiently thorough pathological study. Clinically, some of them behave like chromophobe adenomata; others, however, are hopelessly malignant, infiltrate the base of the skull, and produce multiple cranial nerve palsies.

REFERENCES

[1] BAILEY, P., and CUSHING, H., "Studies in Acromegaly. VII. The Microscopical Structure of the Adenomas in Acromegalic Dyspituitarism (Fugitive Acromegaly)", *Amer. Jour. Pathol.*, 1928, iv, 545.

[2] BAILEY, P., and DAVIDOFF, L. M., "Concerning the Microscopic Structure of the Hypophysis Cerebri in Acromegaly", *Ibid.*, 1925, i, 185.

[3] CAIRNS, H., "The Ultimate Results of Operations for Intracranial Tumours. A Study of a Series of Cases after a Nine-year Interval", *Yale Jour. Biol. and Med.*, 1936, viii, 431.

[4] CUSHING, H., "Partial Hypophysectomy for Acromegaly", *Ann. of Surg.*, 1909, i, 1002.

[5] CUSHING, H., *The Pituitary Body and its Disorders*, 1912. Philadelphia.

[6] CUSHING, H., "Surgical Experiences with Pituitary Disorders", *Jour. Amer. Med. Assoc.*, 1914, lxiii, 1515.

[7] CUSHING, H., "Les Syndromes hypophysaires au Point de Vue chirurgical", *Revue neurol.*, 1922, xxxviii, 779.

[8] CUSHING, H., "Acromegaly from a Surgical Standpoint", *Brit. Med. Jour.*, 1927, ii, 1, 48.
[9] CUSHING, H., "The Chiasmal Syndrome of Primary Optic Atrophy and Bitemporal Field Defects in Adults with a Normal Sella Turcica", *Arch. of Ophthalmol.*, 1930, iii, 505, 704.
[10] CUSHING, H., *Intracranial Tumours*, 1932. Springfield, Ill.: Thomas.
[11] CUSHING, H., "The Basophil Adenomas of the Pituitary Body and their Clinical Manifestations (Pituitary Basophilism)", *Bull. Johns Hopkins Hosp.*, 1932, l, 137.
[12] CUSHING, H., and DAVIDOFF, L. M., "The Pathological Findings in Four Autopsied Cases of Acromegaly with a Discussion of their Significance", *Monograph Rockefeller Institute for Medical Research*, 1927, xxii.
[13] DAVIDOFF, L. M., "Studies in Acromegaly. III. The Anamnesis and Symptomatology in One Hundred Cases", *Endocrinology*, 1926, x, 461.
[14] DOTT, N. M., and BAILEY, P., "Hypophysial Adenomata", *Brit. Jour. Surg.*, 1925, xiii, 314.
[15] DYKE, C. G., and HARE, C. C., "Roentgen Therapy of Pituitary Tumours: Report of Sixty-three Cases", *Proc. Assoc. Research in Nerv. and Ment. Dis.*, 1936, xvii, 651.
[16] EISENHARDT, L., "Long Postoperative Survivals in Cases of Intracranial Tumour", *Ibid.*, 1935, xvi, 390.
[17] HENDERSON, W. R., "Sexual Dysfunction in Adenomas of the Pituitary Body", *Endocrinology*, 1931, xv, 111.
[18] HEUER, G. J., "The Surgical Approach and the Treatment of Tumours and Other Lesions about the Optic Chiasma", *Surg. Gynecol. and Obst.*, 1931, liii, 489.
[19] MARK, L. P., *Acromegaly; A Personal Experience*, 1912. London: Baillière.
[20] PUTNAM, T. J., BENEDICT, E. B., and TEEL, H. M., "Studies in Acromegaly: VIII. Experimental Canine Acromegaly Produced by Injection of Anterior Lobe Pituitary Extract", *Arch of Surg.*, 1929, xviii, 1708.
[21] SCHNITKER, M. T., CUTLER, E. C., BAILEY, O. T., and VAUGHAN, W. W., "The Chromophobe Adenomas of the Pituitary. Pathologic Features and Response to Irradiation Based on a Study of Eighty-one Verified Cases", *Amer. Jour. Roentgenol.*, 1938, xl, 645.
[22] DE SCHWEINITZ, G. E., "Bowman Lecture: Concerning Certain Ocular Aspects of Pituitary Body Disorders, Mainly Exclusive of the Usual Central and Peripheral Hemianopic Defects", *Trans. Ophthalmol. Soc.*, 1923, xliii, 12.
[23] SOSMAN, M. C., Personal communication.
[24] SOSMAN, M. C., "Irradiation in the Treatment of Pituitary Adenomas", *Proc. Internat. Assemb. Inter-State Post-Grad. Med. Assoc. N. Amer.*, 1937, 239.
[25] TRAQUAIR, H. M., *An Introduction to Clinical Perimetry*, 1938. London: H. Kimpton.
[26] VAN WAGENEN, W., "Verified Brain Tumours. End Results of One Hundred and Forty-nine Cases Eight Years after Operation", *Jour. Amer. Med. Assoc.*, 1934, cii, 1454.
[27] VAUGHAN, W. W., "The Place of Irradiation in Acromegaly", *Amer. Jour. Roentgenol.*, 1938, xl, 660.
[28] WALKER, C. B., and CUSHING, H., "Chiasmal Lesions with Especial Reference to Homonymous Hemianopsia with Hypophyseal Tumour", *Arch. of Ophthalmol.*, 1918, xlvii, 119.

In Memoriam

GRAHAM SCALES SIMPSON

It was a great shock to his colleagues and friends all over the country to hear that on Sunday, February 19, Graham Simpson had died suddenly in the early hours of the morning.

He was so full of the enjoyment of life and work during the previous week, during which he had attended the Hunterian Festival of the Royal College of Surgeons, and had been given a clean bill of health by his medical advisers after many months of illness and the ordeal of a surgical interlude for the treatment of actinomycosis of the lung.

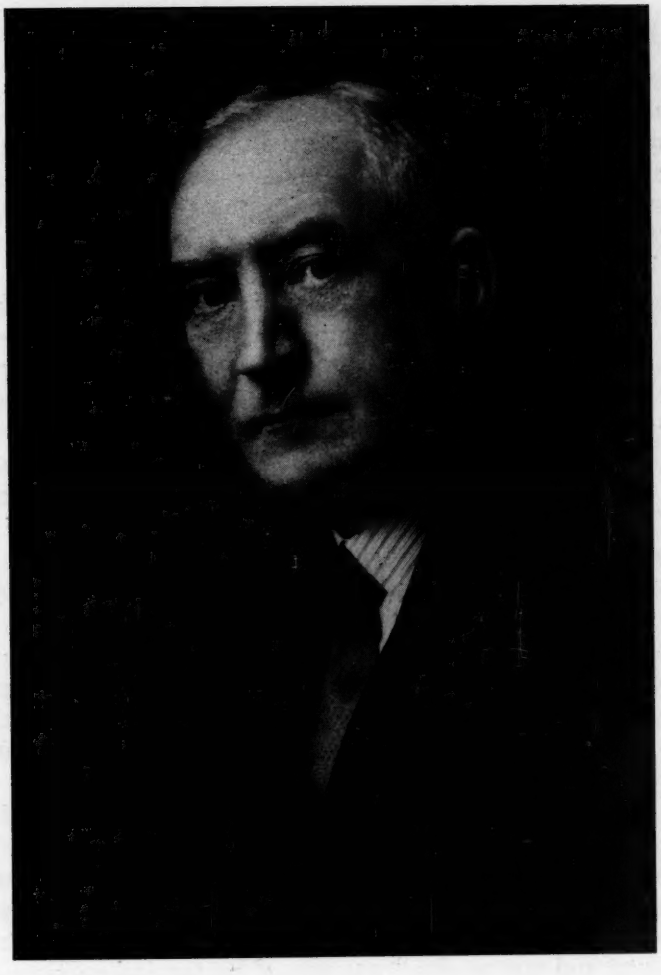
He had written to a friend saying " I have great news for you, I have been asked to give the Bradshaw Lecture ". He had chosen the subject of " Congenital Abnormalities of the Kidney " for this.

The day before he died he had been busily working, and had a busy week in front of him. He awakened soon after 3 a.m. with urgent dyspnœa, and in spite of all that his beloved friend and medical adviser could do for him he passed away a few minutes after 5 o'clock. He had always dreaded the pain of a coronary occlusion, but mercifully in his case the discomfort never amounted to that.

Born at Brighton in 1874, he entered the dental school at Guy's Hospital, obtaining the diploma of L.D.S. in 1896. He had, however, transferred to the medical school, obtaining the diploma of M.R.C.S., L.R.C.P., in 1899, and the F.R.C.S. in 1901. He occupied the post of Surgical Registrar and Tutor at Guy's, and in 1903 was appointed Resident Surgical Officer at the Sheffield Royal Hospital. Three years later he was appointed Honorary Assistant Surgeon, and became full Surgeon on June 16, 1909. He had been Senior Surgeon for more than twenty years when he retired from the active staff under the age limit in 1934.

Ever since he came to Sheffield he had taken an active part in the teaching of surgery. As Resident Surgical Officer he found time to do two teaching rounds each week, these often being in the evenings if his daily routine duties prevented him at other times; and it is in this capacity that he will be remembered by many who were fortunate enough to come under his influence.

He was an excellent clinical teacher, and being himself always a student, he realized the difficulties of the surgical dresser and house surgeon. In later years this was always appreciated by those who attended his post-graduate classes. He made them instantly feel he was their colleague, and he was never supercilious or conceited. He never posed himself and would not tolerate it in others. He impressed upon them the importance of taking a careful and detailed history, and then from the clinical signs led the discussion as to the diagnosis, listening with careful attention and humorous criticism to the suggestions of the most junior student. He would allow no case to go to the operating theatre or post-mortem room without a written diagnosis.



GRAHAM SCALES SIMPSON

1874—1939

He was never tired of inviting students, residents, and junior colleagues to accompany him on his rounds with a cheerful " Let's go and see some cases ". The same spirit pervaded his out-patient department and ward rounds when he was lecturer in surgery and during the five years that he was professor. He always tried to inculcate in his colleagues and juniors the desire for surgical culture.

As an examiner, and he had had a great experience in this work, he always impressed the candidates that he was trying to find out what they did know, rather than the reverse, and always got the best out of them.

To the genuine pleasure and satisfaction of his colleagues, he continued to practise in Sheffield after retiring from the active staff of the Royal Hospital, and retained his appointment as Consulting Surgeon to the Bakewell Cottage Hospital.

He was a man of great tact and friendliness, being a " good mixer ", and he was always interested in, and sympathetic with, the aspirations and anxieties of his colleagues. It was a great help to them to have a man of his integrity and understanding to whom they could go in their need, and who was always ready to give of his time and experience to help others. For him to say " I'll think it over and let you know " was no empty phrase with which to shelve a problem or close an interview. In a few days came a letter in which was the sane criticism and kindly advice sought for; and if possible, he would himself come to discuss the whole matter.

He had been endowed with a rich critical faculty which had been enhanced by his own wide culture in literature, not only surgical but historical and philosophical. It is perhaps this faculty of clear criticism and constructive reasoning which will be missed most by his colleagues both in council and work.

He hardly ever missed a meeting of the Sheffield Medical Chirurgical Society, which he had served as Secretary for a number of years and also as President. His quiet voice, pleasing humour and wit, and keen criticism will be sadly missed by the members. He always added something of interest and instruction to the discussion, and raised it from the level of the commonplace. For eighteen years he has been a most active and valued member of the Editorial Committee of the BRITISH JOURNAL OF SURGERY.

His surgical writing, mostly in the branch of urology, which especially interested him, was clear and trenchant. His critiques on the books of others must always have been appreciated by the authors for their fairness and style.

As an operator he was quiet and imperturbable. He " made haste slowly ", and nothing had ever to be done twice owing to carelessness. " Speed should be an accomplishment and not an aim " was one of his surgical maxims.

He was the first Sheffield Surgeon to be elected to the Council of the Royal College of Surgeons in 1929, and he always regarded this appointment as the greatest honour and privilege he had received. At the time of his death he was taking great delight in the preparation of the Bradshaw Lecture which he was to have delivered.

His lovable personality and even temperament were especially remarkable during his recent illness, and when he suffered from a severe burn of both hands and forearms two years ago, from each of which he made a wonderful recovery.

He died, as he would have wished, in harness. He will be greatly missed by a large circle of those who have been his patients, and others who are proud to have been reckoned amongst his colleagues and friends.

CRITICAL REVIEW

THE SURGERY OF THE ADRENAL CORTEX

By L. R. BROSTER, O.B.E.
SURGEON, CHARING CROSS HOSPITAL, LONDON

"*Alia ex alio clarescit.*"

Our sympathy towards disease is determined by its causes: in hereditary disease it is directed towards the innocent victim; in acquired disease it is more reserved; whereas in unexpected illness it is spontaneous. But perhaps it is more touched by those individuals, who, escaping disease in the ordinary accepted meaning of the word, and enjoying normal health, find themselves trapped in the shifting sands of nature. To develop and deviate from the normal standards of life, either physically or mentally, is not only to acquire an inner consciousness of ostracism, but to live the life of a pariah. The number of such cases is comparatively small, and their seclusion in the past was no doubt intensified by the fact that there was little hope of alleviation by medical means. It is small wonder, therefore, in dealing with a deserving and delicate subject such as this, that definite risks should be taken in the hope that the study of the abnormal might shed some light on those biological processes which are concerned with normal development and behaviour. Work in this direction was started at Charing Cross Hospital just over a decade ago by a study of the adrenogenital syndrome. The original surgical and clinical observations which form its groundwork have been developed and expanded by pathological and biochemical investigations. It is difficult to speak with any finality on a subject which presents itself as a picture in which the central figures are beginning to stand out but whose background is still in a kaleidoscopic state. Experimental methods constantly change and must remain *sub judice* till they satisfy clinical needs. It is only when their results harmonize with the general theme that they can be painted in.

Clinical Study of Sex Changes.—The appearance of abnormal sex characters in individuals has been known from time immemorial, and has been a favourite theme for writers, sculptors, and painters alike. In the earliest records such individuals were held up as objects of veneration, but in the middle ages a reaction set in, and they were regarded as unclean and unnatural, and as a consequence became objects for persecution and ostracism.

To evaluate the human equation is a simple matter if regarded as the division of the species more or less equally into two different sexes; but the sex equation of the individual is quite a different proposition, and by no means constant. One obvious generalization on this subject is the comparative instability of the female sex, as the masculinization of the female is a far more common event that the femininization of the male. To such an extent may such changes occur that it is impossible in some individuals to determine the true nature of the sex by ordinary methods of examination. These observations serve to emphasize the

essential bisexual nature of each individual, and it is obvious that the major problem is to try to discover its cause.

Now changes of this kind may become evident soon after birth, indicating that they must be due to some variation or aberration of the normal governing processes of growth and sex development dating from the earliest phases of fœtal life. The fact that they more commonly occur after puberty, when the secondary sex characters appear, suggests that the cause remains inherent but latent, and can be activated in later life during times of endocrine stress. For many years the association between sexually abnormal individuals and adrenocortical tumours had been known in medical literature from post-mortem examinations, but clinically the point was definitely established in a case published by Holmes,[1] in which Sargent successfully removed an adenoma of the adrenal cortex, which led to the disappearance of the heterosexual symptoms (1925).

FIRST PHASE: ADRENOGENITAL SYNDROME

In 1927 a further stage was reached when Broster removed an enlarged and hyperplastic adrenal for a similar condition at Charing Cross Hospital. Such clinical evidence definitely established a pathological basis for the adrenogenital syndrome in the cells of the adrenal cortex. However, the cortical cells did not show any marked histological variation from normal, and

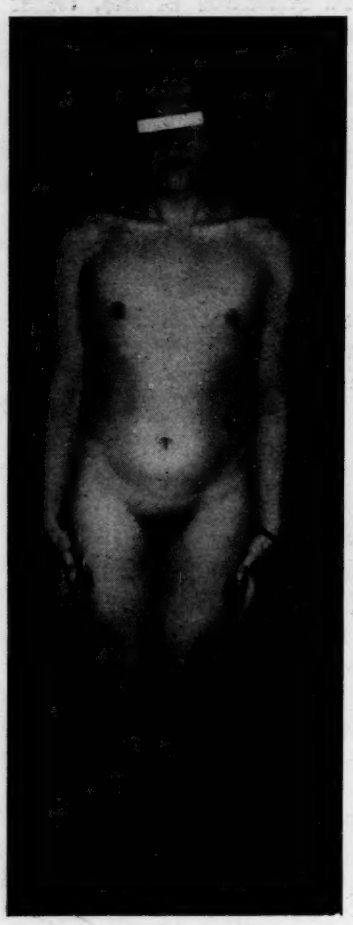


FIG. 647.—J. du B., aged 13 years. *Group* I, pre-pubertal virilism.

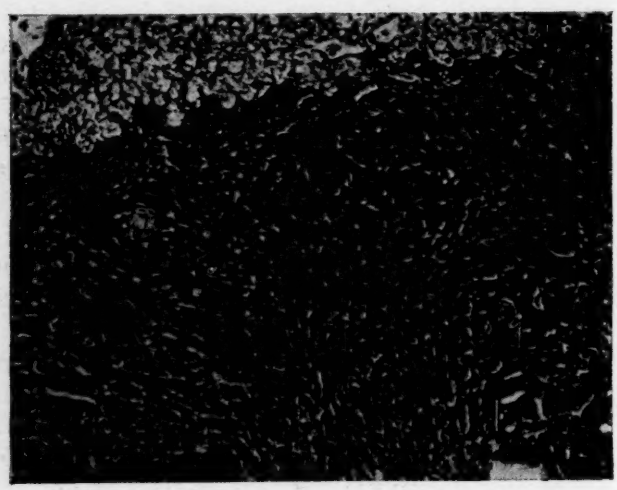


FIG. 648.—J. du B., aged 13 years. Reaction, very strong positive. (× 110.)

it was difficult to see how they acted as a causative agent. In the meanwhile several cases had been collected at Charing Cross Hospital upon which unilateral adrenalectomy had been performed, and an article in this JOURNAL was published by Broster and Gardiner-Hill[2] (1932) setting out a clinical

classification, with histological details by Greenfield. In the histological illustrations of that article, sections of the adrenal cortex from different groups of patients were shown, and although the structure, shape, and arrangement of the individual cells in the different layers did not show any abnormality, one observation was pointed out by Greenfield—the presence of pigment bodies in the cells chiefly of the enlarged zona reticularis.

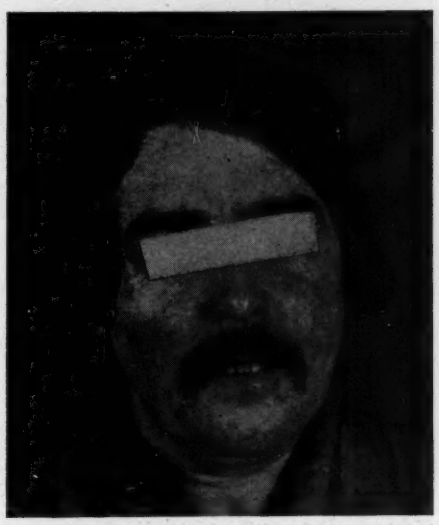


FIG. 649.—A. T., aged 40 years. *Group* II, marked virilism.

The clinical classification adopted by Gardiner-Hill at that time has proved very satisfactory, and as it stressed questions of degree which are necessary for clinical purposes, it will only be briefly recapitulated here, with some additions gathered in the light of further experience.

Clinical Syndrome.— Virilism was defined as the appearance of secondary male sex characters in the female, with a retrogression of the normal female characters and functions. The changes to the male sphere are hypertrichosis of the male type and distribution, alterations in the bodily contour, muscular development, acne, enlargement of the clitoris, and deepening of the voice. In the female sphere there is lack or absence of breast development; loss of normal subcutaneous fat; underdevelopment of the internal and external genitalia; degenerative changes in the ovaries

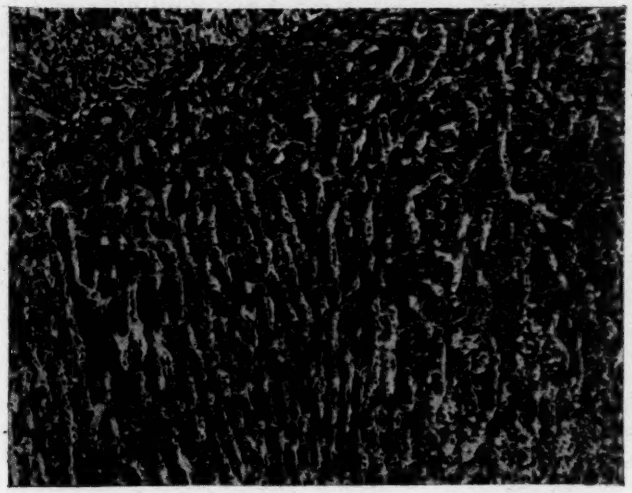


FIG. 650.—A. T., aged 40 years. Reaction, strong positive. (× 110.)

leading to amenorrhœa, either primary or secondary, or ovarian dysfunction. In addition there may be changes in psychological outlook. In hyperfunction of the adrenal cortex these changes come on slowly, and the earlier the onset the greater the degree of change. In tumour they are more abrupt.

These patients fall naturally into three main groups: *Group I*, Pre-pubertal (primary amenorrhœa) (*Figs.* 647, 648). *Group II*, Post-pubertal (secondary menstrual disturbances) (*Figs.* 649–654). *Group III*, Post-pubertal (associated with a polyglandular syndrome).

FIG. 651.—E. P., aged 34 years. *Group* II, fairly marked virilism.

Group I.—In these patients normal feminine development does not take place at puberty, and there may be some stigmata of masculinization before this time, such as an enlarged clitoris, precocious development of pubic hair, a deep voice, and muscular development. The menses never start, the breasts fail to develop, the configuration is male, and the feminine organs are rudimentary. These individuals approach the intersex type, and it may be a matter of difficulty to determine their sex. Their sexuality may be normal, indifferent, or frankly homosexual. Their adrenals are large and pigmented. The time of onset of the lesion had been a matter of speculation until the larger left adrenal was

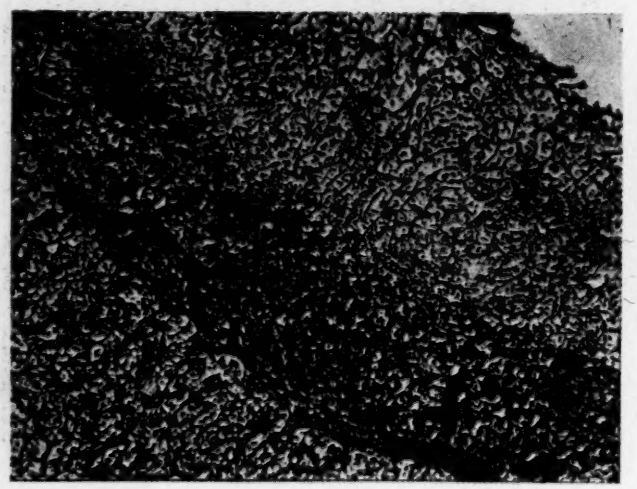


FIG. 652.—E. P., aged 34 years. Reaction, moderate positive. (× 110.)

removed from a girl at the age of 16, whose opposite adrenal had been felt to be three or four times its normal size at the age of 3, during an operation for removal

of her appendix. The plight of these individuals is a sad one. Although they give the appearance of being strong and robust, the condition, if left, becomes progressively worse. This has been observed in photographs taken at different ages. They age prematurely, and their stormy reaction to operation is perhaps a good indication of a lowered physical resistance.

FIG. 653.—R. M., aged 26 years. *Group* II, moderate virilism.

Group II.—Members of this group are much more numerous, and the stigmata of the disease are less obvious and more variable. Their psychological reaction to the growth of hair after a period of normality after puberty is distressing, and takes precedence over whatever menstrual dysfunction there may be. These are the main symptoms for which they present themselves on examination. Because of their condition they either shy at marriage, shun society, are autosexual or frankly homosexual. It is probable, too, that their threshold of fertility is lowered. It is a difficult problem to decide what to do with these people, because, apart from clinical and psychological manifestations, there is little help to guide the surgeon in his choice of case for operation. Where there is marked hirsuties and menstrual dysfunction, the task is easy. For very marked

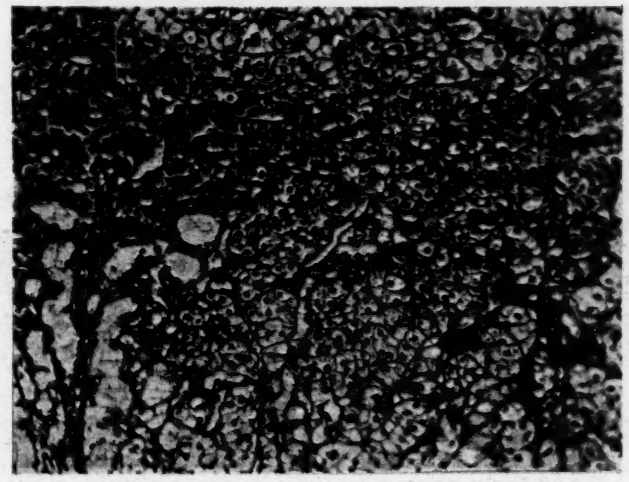


FIG. 654.—R. M., aged 26 years. Reaction, weak positive. (× 185.)

hirsuties, even with more or less normal menses, operation is satisfactory. Where the hirsuties is not so marked, but the menstrual dysfunction is pronounced, operation is worth while. Of the two symptoms, hirsuties is more amenable to operation than is the menstrual function, but this can be stimulated by organotherapeutic means.

Beyond the range of these sub-groups there are numerous women with milder degrees of hypertrichosis who have been considered unsuitable for operation. Hormonal treatment has been tried for the latter; it improves the menstrual cycle and flow, but otherwise no great success has attended our methods. With regard to hair, we have had no experience with the Asiatic or Negro variety, where apparently there is little disparity in the growth of hair between the sexes. In the European the female hair is said to be less strong in growth. As the beard is the symbol of manhood, it cannot be said that some of the feminine varieties are far behind in this respect. Judging from the distribution and growth in our patients, it is a question whether the various fashions in beards have not been dictated more by natural outcrop than by the ingenuity of tonsorial art. Our series has shown a moustache which would do justice to any Sergeant-Major of the Guards; and a French beard typical of the immaculate Second Empire, which now-a-days appears sporadically on the British stage; but Piccadilly weepers have never stood a chance! The effect of hair on the female is a mesmeric one. They will try every artifice for removing it, but the mere suggestion of a razor leaves them aghast. There is a rooted prejudice that shaving stimulates the growth of hair, but there is no scientific confirmation of this.

To a lesser extent than puberty, the stress of pregnancy appears capable of activating virilism. We have had examples of virilism following the first or later pregnancies in the mother. One case history showed that hirsutism began almost simultaneously in a mother and her daughter six years after the pregnancy. Twins have on several occasions shown evidence of instability. In one instance the female co-twin was operated upon for virilism. The male partner had died at birth. This case seems analogous to the free-martin in cattle, where the female is masculinized by the male co-twin when joined together by a common placental vessel. In another pair of uniovular twins, both of the male intersex type, brought up as females, the family history revealed that they were the descendants of intermarriages between two families with male twins on the male and female twins on the distaff side, nearly a century before.

There is evidence from family histories of two endocrine abnormalities present in the same individual, and of the same or different endocrine abnormalities among different members of the same family.

Group III.—These are all fat whiskered women veering towards Cushing's syndrome, and are not suitable subjects for adrenalectomy. It must be remembered, however, that Cushing's syndrome may equally well be caused by an adrenal carcinoma as by a basophil adenoma of the pituitary.

SECOND PHASE: A NEW STAIN FOR VIRILISM

The next stage in the elucidation of the problem of the part which the adrenal cortical cells played in the production of virilism was a most important one. In 1933 Broster and Vines[3] published a monograph which drew attention to the fact that Vines had discovered a new stain for virilism. It is a differential stain whereby the cortical cells of the adrenal glands removed at operation for virilism assumed quite a different colour from those of the normal glands—the so-called Ponceau fuchsine stain. The cytoplasm of the cells, chiefly of the inner layers of the cortex, stained a vivid red colour with Ponceau fuchsine, in contrast to the

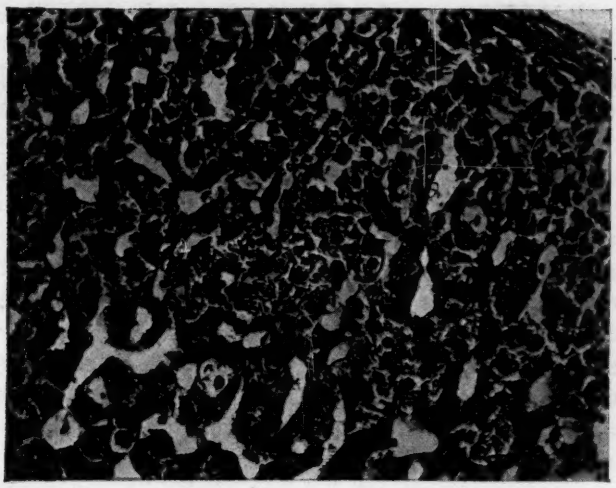


FIG. 655.—Male, fœtal age 10·5 weeks. Length 67 mm. Reaction, positive. (× 185.)

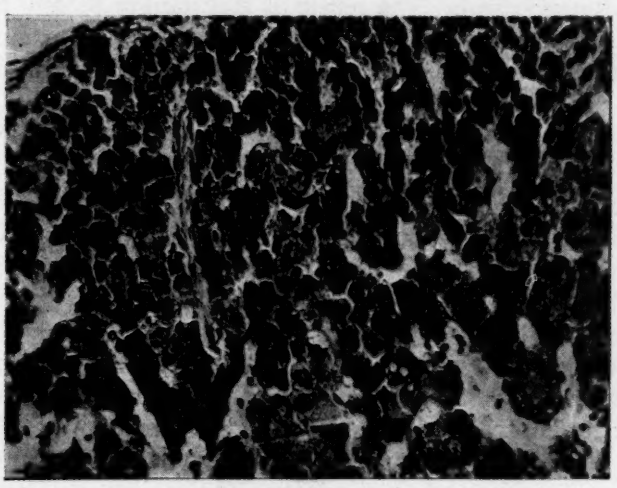


FIG. 656.—Female, fœtal age 11·5 weeks. Length 92 mm. Reaction, weak positive. (× 185.)

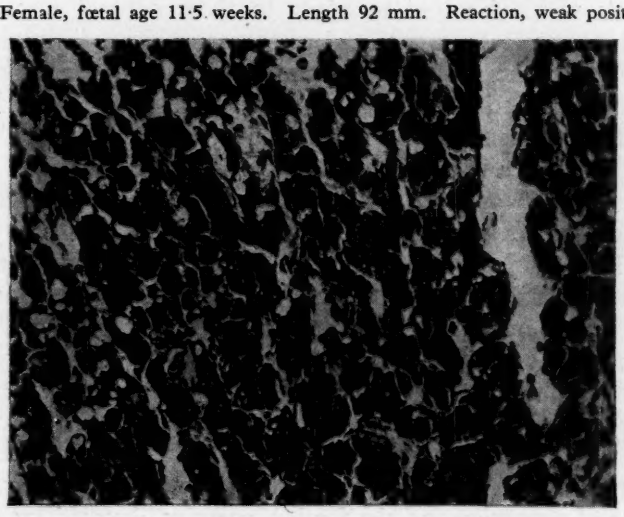


FIG. 657.—Female, fœtal age 13·5 weeks. Length 136 mm. Reaction, positive. (× 185.)

blue colour of the normal cells, which took the counter stain, aniline blue. The avidity of the cells for this stain under different clinical conditions is a matter of degree, and the degrees of its intensity are seen in *Figs.* 648, 650, 652, and 654. It now became obvious that we were dealing with an altered physiological activity of the adrenal cortical cells in relation to virilism. This stain has been corroborated by others in this country and abroad.

Vines, meanwhile, had made an extensive study of this stain, and found it was taken up by the acidophil cells of the pituitary, the interstitial cells of the testis, and the cells of the young corpus luteum. In addition, a series of some sixty fœtuses had been collected, and Vines again was able to show that the fuchsine reaction was positive temporarily in the fœtal cortical cells of both sexes. In the male it was strong between the 9th–20th week (*Fig.* 655), in the female less marked and of shorter duration between the 11th and 17th week (*Figs.* 656, 657). At the end of these times it normally disappeared. In two fœtuses at term the persistence of this stain in the adrenal cortex was associated with marked hypertrophy of the pituitary gland. The result of this inquiry to date left the position that a special staining reaction associated with clinical masculinization of the female had been discovered, and that it was present temporarily in the cells of the adrenal cortex of both sexes in the early stages of fœtal life.

THIRD PHASE: THE MALE HORMONE

1. Biological Tests for Male Hormone.—It was now surmised that the Ponceau fuchsine reaction was in some way connected with the production of the male hormone, or its precursor by the adrenal cortex. Evidence concerning this relationship could only be procured by biochemical investigation, and work to this end was embarked upon by Patterson. The most promising lines of research seemed at the outset to lie in the study of the male hormone excretion in the urine, and the male hormone activity of the glands removed at operation. At this time, though male hormone was known to be present in male urine, it had not been described as present in female urine, and, further, adequate methods for its extraction were lacking. A preliminary inquiry into the problem of what technical methods would be best to apply to these adrenal cases which would extract their urinary male hormone, and at the same time distinguish them from normal females, led to the adoption of a method involving the collection of seven to ten days' urine, extracting this after suitable acidification with larger volumes of benzene, and subsequently working up the benzene extract to a form which was suitable for assay by the capon method, whereby the growth of comb is taken as an indication of the amount of male hormone present. Such assays were kindly undertaken by Dr. Alan Greenwood, a well-known authority on this type of biochemical investigation. It thus became possible to show that most of the authentic cases of adrenal virilism excreted appreciable quantities of male hormone, whereas, by the same method of investigation, normal female control cases gave either negative results or only traces of active substance. Further work, however, clearly demonstrated that after the completion of such extraction as has been described above, drastic acid hydrolysis would enable further quantities of male hormone to be extracted both from adrenal cases and normal female subjects. For this reason it was necessary to distinguish between the active substance in the original form of extraction and the further quantity liberated by acid hydrolysis.

Accordingly they were respectively designated the 'free' male hormone and the 'bound' male hormone.

Confining attention first to the 'free' hormone and comparing pre-operative and post-operative urine samples, it soon became evident that in the majority of our patients submitted to unilateral adrenalectomy the hormone excretion was diminished as a result of the operation.

2. Biochemical: Isolation of Male Hormone.—Collaboration with Professor G. F. Marrian, of Toronto, enabled us to reach a further stage in our quest. Extracts were prepared from two typical *Group I* cases and despatched to Toronto for chemical investigation. In due course Professor Marrian and Dr. Butler[4] isolated from them a new chemical compound pregnane-triol ($C_{21}H_{36}O_3$), a substance allied to pregnane-diol, previously isolated from pregnancy urine, which in turn is related to progesterone, the corpus luteum hormone. The excretion of this new compound was also reduced by operation. The determination of the exact nature of the male hormone, or hormones, present could not be simultaneously undertaken on account of the shortage of material represented by these first extracts. Later, however, when it became possible to supply greater amounts of material, Professor Marrian and his colleague[5] succeeded in isolating in crystalline form isoandrosterone ($C_{19}H_{30}O_2$), along with a number of other steroid substances related to the sex hormone group.

Colour Test for Male Hormone.—This work on the isolation of a number of steroid substances which, so far as is known at the present time, are specific to adrenal virilism urines, has stimulated research in yet another direction. Dr. Patterson and Miss McPhee have in the last year or so been conducting a study of the colour reaction for steroid ketone substances first described by Zimmermann,[6] and later developed by Oesting[7] in America and by Callow[8, 9] in this country, with special reference to its application to cases of adrenal virilism. It is early yet to report with any finality upon the results achieved. However, it may be said that by its means, according to the quantitative determination of the sterone excretion, the groups may be fairly clearly demarcated, with *Group I* giving by far the highest values, and *Group II* in turn yielding in general much larger figures than are represented by the normal female control range. Those few patients who have been found to be inside the normal range represent the mildest and earliest cases. Moreover the immediate effect of unilateral adrenalectomy is demonstrable just as clearly by the fall in sterone excretion as by the more elaborate investigation of the androgenic excretion —a finding which further substantiates the direct relation of the adrenal gland to the substances which are collectively styled the 'sterones' of the urine.

The fact that the colour reaction can be studied upon relatively small samples of freshly voided urine, in contrast to the biological assays which require prolonged collections, has enabled a closer investigation to be made into the different hormonal fractions. This has revealed that the original ideas of 'free' and 'bound' hormones require some re-modelling. The two fractions into which the hormonal activity can be divided are not exactly as originally conceived, in that during the prolonged collection some of the hormone is liable to be broken down from its state of conjugation. The results of our earlier experiments, such as those concerned with the obtaining of 'free' hormone from adrenal cases, against negative results for normal females, are therefore more to be interpreted as generally reflecting qualitative and quantitative differences in the hormones of the two sets of cases.

PSYCHOLOGICAL

It has been apparent from our earliest observations that when the sexuality is abnormal in virilism, it has shown—like the physical characters—a tendency to return to normality after operation. Theoretically, this suggests, as do our clinical conclusions, that under certain circumstances the psyche may be amenable to hormonal influences involved in the adreno-pituitary-hypothalamic mechanism, and that the divorce between physical and psychological medicine is more apparent than real. It certainly offers new and unique scope to the study of psychological medicine. It is an aspect of this syndrome beyond the compass of the clinician, and the work on this subject has been specially dealt with by Dr. Clifford Allen in *The Adrenal Cortex and Intersexuality*.[10] From each stage in the progress of this work the conviction has grown that certain types of abnormal behaviour are due to organic causes, which suggest that the present medical outlook on this subject will have to be readjusted. Any change of opinion of this kind is of special interest to such executive authorities as the social and legal, who have to deal with their consequences. That such authorities are already alive to these possibilities is shown in the report of the Standing Committee of the Criminal Justice Bill.[11]

INTERSEXUALITY

Among the patients who have presented themselves for examination there have been several in which the true sex was a matter of considerable doubt. This applies chiefly to the intersex type with hypospadias, which are difficult to differentiate

TABLE OF INTERSEXUALITY.*

CLINICAL DIAGNOSIS	NO. OF CASES	UP-BRINGING	GONAD	GENITALIA		SEXUALITY
				Female	Male	
Secondary virilism	25	F.	Degenerate ovary	Small uterus and vagina	Clitoris normal or slightly enlarged	Mostly female, some male
Primary virilism	5	F.	Functionless ovary	Infantile uterus and vagina	Penile clitoris	2 indefinite, 2 male, 1 female
True hermaphroditism	1	M.	Ovotestis	Infantile uterus	Penile hypospadias	Male
Cryptorchid	1	F.	Small and immature testis in position of ovary	Infantile bicornate uterus	Penile hypospadias	Indefinite
Cryptorchid	1	F.	Large testis in position of ovary	None	Marked penile hypospadias	Male
Partial cryptorchid	1	F.	1 abdominal, 1 inguinal testis	None	Marked penile hypospadias	Female
Bilateral undescent	4	F.	Inguinal testes	None	Penis cleft scrotum	3 female, 1 male

* From *The Adrenal Cortex and Intersexuality*. London: Chapman & Hall.

from pre-pubertal virilism (*Group I*). Those we have observed are presented in the schema on page 934, which shows variations in degree, through true hermaphroditism, from female to male.

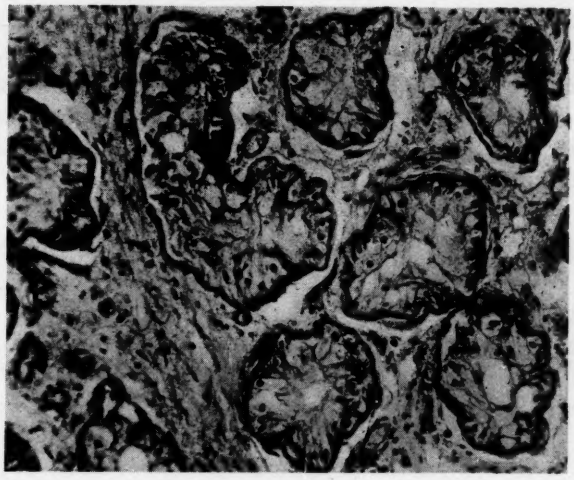


FIG. 658.—Unilateral ectopia, age 16. Post-pubertal group. Atrophic and fibrotic changes are well marked and the interstitial cells are absent. (*Figs.* 658–660 *by kind permission of the 'Journal of Pathology'.*)

It can be seen that starting with secondary virilism there is a progressive masculinization of the female; the feminine characters gradually decline while those of the male progressively increase. In fact complete feminine

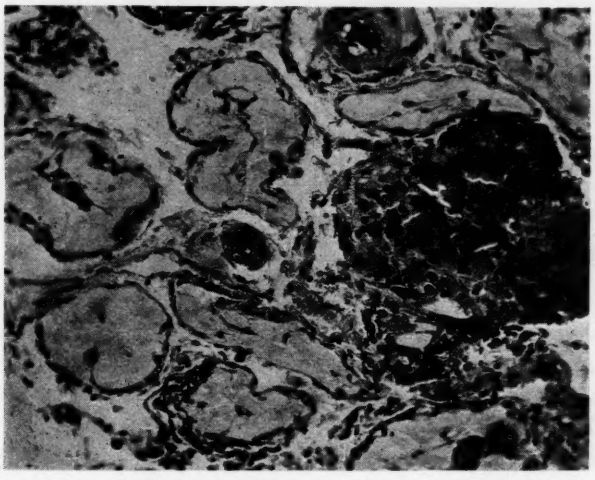


FIG. 659.—Bilateral ectopia, 'female', age 16. Complete atrophy of the tubules with an islet of hyperplastic interstitial tissue.

obliteration does not take place till after the intersex group is reached, where a small immature bicornate uterus was found in association with embryonic testes in the position of the ovary. In the following group with more advanced testicular development, still in the position of the ovary, the uterus has disappeared, and the

external genitalia are approaching those of the male—penile hypospadias. From this point onwards, the cleft scrotum, the last remains of the utero-vaginal canal, becomes fused, and the testes are found in varying degrees of undescent. From testes collected and removed at operation from these patients, Vines has pointed out that undescended testes are all similar histologically till puberty. After this time in unilateral undescent there is a progressive fibrosis (*Fig.* 658), whereas in bilateral undescent there is (*a*) a marked increase in the interstitial cells without spermatogenesis (*Fig.* 659) or (*b*) a slight increase in the interstitial tissue with normal spermatogenesis (*Fig.* 660). This work is in need of further elaboration; indeed, the one type with marked increase of the interstitial elements suggests

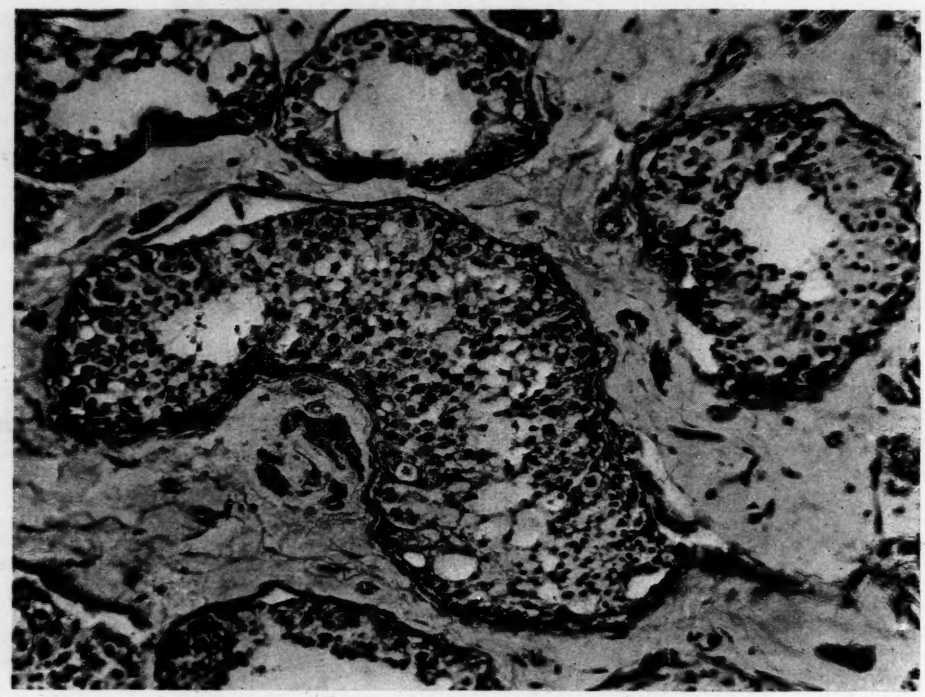


FIG. 660.—Bilateral ectopia, 'female', age 32. Active spermatogenesis is present: small groups of interstitial cells are present in normal numbers.

that the condition is primarily endocrine and associated with the adrenogenital syndrome. If this is so then it lends support to treatment of this condition by organotherapeutic means.

Theory of Intersexuality.—To revert to the classification which we have presented, it is necessary to come to some conclusion as to how these intermediate forms of sex development are produced. The gradations are so smooth that it is difficult to imagine that they are due to different causes, but rather that they represent a series of pictures due to modifications in one form of control which becomes disorderly in the earliest stages of fœtal development. Crew[12] states that the sex chromosome mechanism is the sex determining mechanism, but under certain circumstances this may be overridden and the sex determined in other ways. Now attention has been drawn to the fact that the female embryo passes

through an early and transient phase in which the cells of the adrenal cortex give a reaction similar to those of adult virilism, which is associated with the presence of male hormone biochemically. Should this 'male phase' in the female fœtus be stronger than normal, as is suggested by the differences in intensity of the staining reaction, or be unduly prolonged, then it may be expected to exert a marked effect on the rapidly growing and plastic embryo. Indeed such a process as this supports Crew's contention and suggests that the original genetic bias may be superseded or replaced by an abnormal endocrine one. The time factors for the appearance of each of these correlated with sex development are taken from Vines's table :—

TIME OF FŒTAL RELATIONSHIPS

Fuchsine stain in fœtus only present during
Male, 9–17th weeks
Female, 11–14th weeks

Weeks	
5½	Indifferent sex glands
6	Testes and adrenals
6–8	Ovary. Utero-vaginal canal commences
9	Interstitial cells of testes Sex differentiated structurally End of chromosomal phase
12–14	Pituitary solid gland
13–15	Acidophil and basophil cells
15	Fuchsine stain disappears from female
12–16	Utero-vaginal canal separated

It must be noted that the pituitary gland makes its appearance soon after the appearance of the 'male phase' in the adrenal cortex, and if this is abnormal then it acquires a defect which it continues to exercise in those functions which it subsequently controls. In these intersex problems, therefore, regard should be paid to Vines's contention that the adrenal cortex plays the part of an accessory bisexual gland, capable of secreting androgens and œstrogens under control of the pituitary; that up to the time of puberty every individual is essentially bisexual, becoming functionally monosexual only when the gonad is fully developed at puberty, and tending to relapse into bisexuality again after the menopause or when the function of the gonad ceases. Biochemically Patterson has shown that the intersex types conform to those of primary virilism in having an excess of male hormone, which has not been readily obtained from normal controls of either sex.

OPERATIVE INTERFERENCE

The technique of operations on the adrenal gland have been described by Crile,[13] Young,[14] and others. Technically the operation of unilateral adrenalectomy may prove very difficult, and unexpected bleeding deep down may be encountered. In pre-pubertal virilism the post-operative convalescence is stormy, the patient passing through a stage of marked tachycardia and excitability much resembling acute hyperthyroidism. In our series of about fifty cases at Charing Cross Hospital there has been one death due to pulmonary collapse and a persistent thymus.

The operation is performed in two stages: first, a preliminary laparotomy to palpate which adrenal is the larger, to corroborate the adrenogenital syndrome and exclude arrhenoblastoma and the possibility of adrenal rests. The larger

adrenal is removed about a fortnight later. Originally the transpleural route was used. This gives the best access, and the diaphragm is easier to control after it has been incised, but convalescence is prolonged owing to delay in the expansion of the lung. The high kidney incision is now used for access, excising the last rib when small, otherwise fracturing it at its neck. Suitable instruments designed for the operation are a great help. As results show, the procedure is comparatively safe, but it has the disadvantage of entailing two operations.

It is quite probable that in the majority of *Group II* (post-pubertal) the two operations could be safely combined into one, but an abdominal incision is a further respiratory embarrassment to a patient whose diaphragm has already been incised and whose pleura is liable to be accidentally punctured.

To overcome these disadvantages Hugh Young,[14] of Baltimore, has adopted a routine of a bilateral exposure and removal of portions from each gland. This method enables both adrenals to be visualized, but on the other hand it does not make certain of a differential diagnosis such as arrhenoblastoma, and must carry a certain risk of Addison's disease from bilateral thrombosis of the main adrenal vein. Injections of air into the lumbar tissues in an attempt to show the size of the adrenal glands radiologically is a method which has been tried in America, but I am given to understand it is a procedure not entirely free from risk. Distortion of the renal pelvis by adrenal tumour, as shown either by uroselectan or retrograde catheterization, must be a rare and late event, and such a tumour will probably be detected on a plain X-ray film. A useful guide in determining which adrenal to remove, is to choose the gland on the same side as the larger and more cystic ovary.

Results.—In *Group* 1 there have been 7 cases. The glands in this series have been much enlarged and pigmented, the largest in the series resembling a normal spleen both in colour and size. The earliest case in this group has not shown much change. After ten years there is a considerable quantity of bound hormone still present in her urine, but we have no figures for comparison as her operation was performed long before our chemical tests were started. It is satisfactory to note that there has been no further progress of her symptoms. Theoretically she should be improved by a hemi-adrenalectomy of the remaining gland. A second case in which excess of free male hormone and of Marrian's new substance was found, both being reduced by operation, has under hormonal treatment begun to menstruate for the first time two years after her operation. We have recently operated on a child of 7 in this group, and her development through puberty should make an interesting comparison with the others, who have all been adults. When chosen with care, *Group II* is a satisfactory one for operation; the physical disabilities are ameliorated and the psychical reaction improves—both towards the normal sexual sphere. It gives the individual a means of dealing more effectively with disfiguring facial hirsuties. It should be explained that a partial operation does not confer a total disappearance of all symptoms, but it does arrest their progress. Border-line cases present a difficulty, especially when operation has been refused, for their psychological reaction is sometimes worse than those who may consider that operation has not come up to their own expectations. The capon test takes too long to be of any help in determining operation, and when it shows a very high urinary androgenic content the symptoms are obvious as well. The new colour test, which can be performed from 24 hours'

collection of urine, may prove helpful in deciding which of this group should be operated upon, and is now being investigated from this point of view.

DISCUSSION ON THE BIOLOGICAL ASPECTS OF SEX HORMONES

So far we have been concerned mainly with the excess of male hormone in the adrenogenital syndrome due to hyperplasia. In adrenal tumour a male comb growth was obtained by Slot[15] in a virile woman, but no excess was found in the tumour. Other observers have also found an excess of a male substance with tumour. Of special interest in contrast to these cases is one published by Levy Simpson,[16] who found an excess of œstrogen in an adult man undergoing feminization from adrenal carcinoma. The excess of hormone and the feminine characters disappeared after its removal, but both returned coincident with metastases. He concludes that the clinical and biological evidence suggests that the tumour was directly or indirectly responsible for the excess of female hormone. In *The Adrenal Cortex and Intersexuality* a case is shown of a boy of 7 with precocious sex development due to carcinoma with an excess of male hormone (*Figs.* 661, 662). Kepler[17] published two cases of adrenal tumour, one of an adult virile woman with 19 rat units of œstrin and the other of a girl of 2 with precocious feminine development in which no œstrin was found. Tumours are rare, and as a rule show a wide symptomatology, and sufficient biochemical data are not yet available for their correlation. Thus we are faced with the problem of an excess of male-growth substance in women becoming virile, and an excess of œstrin in a male becoming feminine. The existence of hormone belonging to one sex which is also found in the opposite sex, though paradoxical, is now generally accepted; it is unfortunate that we cannot as yet obtain any accurate estimation of sex hormone activity in

FIG. 661.—J. B., aged 6½ years.

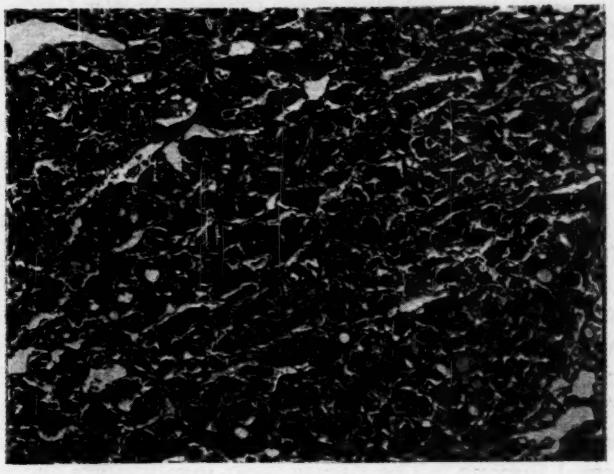


FIG. 662.—J. B., male, aged 6½ years. Isosexual precocity. Reaction, positive. (× 185.)

the normal individual, or in those suffering from minor hormonal disturbances. What evidence there is points to the fact that the adrenal cortex is the main source of the excess hormones found, and on clinical evidence Vines's conception of the bisexual role of the adrenal cortex receives support. Our present methods of bio-assay are not delicate enough to prove this point. Patterson has made extracts of actual glands removed at operation which Greenwood has injected directly into the comb of capons, but it is obvious that the amount of hormone is too small to give any reliable evidence. The slight local growth which has taken place in some of these would tend to favour the presence rather than the absence of such hormone. The actual amount of hormone present in a gland at any particular moment must of necessity be very small, and only continuous secretion or cumulative storage in the body makes its recovery possible from the urine.

The alternative theory favoured by Young[14] and others is founded on the old theory that it is the ovary which plays the part of a bisexual organ—the cortex being feminine and the medulla potentially male. Refuting this idea is the fact that virilism may occur and even be progressive after operative removal of both ovaries. Two cases in our series support this contention. Vines has also had the opportunity of examining many portions of ovary removed at operation for virilism, and he finds that they are uniformly cystic and degenerate, pointing to the inhibition of the feminine part of the ovary rather than to any overactivity of its medulla, of which he can find no evidence.

In the elucidation of these problems bio-assays are becoming increasingly valuable, but as yet show no evidence of supplanting clinical observation and experience. In this discussion of what is virtually a matter of steroid metabolism it is obvious that one of the most important factors concerned is that of tissue growth.

It has been shown that the growth and development of abnormal male characters in the female is associated with the excretion of excess of male hormone, which is diminished in amount by the operation of unilateral adrenalectomy. The clinical effect of operation is not only to inhibit further growth of the male type, but to alter and divert it into normal feminine channels. A case has also been quoted of the reverse process occurring in a man undergoing femininization from adrenal tumour. The tissues most involved are the subcutaneous fat and the skin and its appendages. The change is of a selective kind, being more noticeable in relation to the secondary sex characters. In contrast to this innocent but differential tissue growth is to compare the work of Dean Lewis and Geschickter.[18] In their bio-assays of simple breast tumours they have found œstrin present in excessive amount. Further, they have demonstrated that direct injections of œstrin into the breast of girls has been followed by marked virginal hypertrophy. These are illustrations of a response in tissue growth and activity *in vivo* of a selective and local kind. It is impossible in the present state of our knowledge to say whether these hormones have any direct influence on tissue growth or whether they act indirectly via the pituitary gland. Unilateral adrenalectomy has served to place the study of steroid metabolism on a more practical basis and has opened up paths for its study in other fields of medicine. It follows the same principles in surgery which have been learned from other glands in the endocrine series—that hyperfunction of a gland can be corrected by its removal, whether partial or complete.

REFERENCES

[1] HOLMES, GORDON, *Quart. Jour. Med.*, 1925, xviii, 143.
[2] BROSTER, L. R., GARDINER HILL, H., and GREENFIELD, J. G., "The Adreno-genital Syndrome with Cortical Hyperplasia; The Results of Unilateral Adrenalectomy", *Brit. Jour. Surg.*, 1932, xix, 557.
[3] BROSTER, L. R., and VINES, H. W. C., *The Adrenal Cortex*, 1933. London: H. K. Lewis.
[4] BROSTER, L. R., and VINES, H. W. C., "A Note on the Adrenal Cortex", *Brit. Med. Jour.*, 1937, i, 662.
[5] BUTLER, G. C., and MARRIAN, G. F., *Jour. of Biol. Chem.*, 1937, cxix, 565; 1938, cxxiv, 237.
[6] ZIMMERMANN, W., *Zeits. f. physiol. Chem.*, 1935, ccxxxxiii, 257; 1936, ccxlv, 47.
[7] OESTING, *Proc. Soc. Exper. Biol. and Med.*, 1937, xxxvi, 524.
[8] CALLOW, R. K., *Proc. Roy. Soc. Med.*, 1938, xxxi, 841.
[9] CALLOW, N. H., CALLOW, R. K., and EMMENS, C. W., *Biochem. Jour.*, 1938, xxxii, 1312.
[10] BROSTER, L. R., VINES, H. W. C., PATTERSON, J., GREENWOOD, J. G., ALLEN, CLIFFORD, MARRIAN, G. F., and BUTLER, G. C., *The Adrenal Cortex and Intersexuality*, 1938. London: Chapman & Hall.
[11] *Standing Comm. Criminal Justice Bill*, 1939, Feb. 7, 25. London: H.M. Stationery Office.
[12] CREW, F. A. E., *Sex Determination*, 1933.
[13] CRILE, G. W., "Clinical Studies of Adrenalectomy and Sympathectomy", *Ann. of Surg.*, 1923, lxxxviii, 470.
[14] YOUNG, *Genital Abnormalities, Hermaphroditism and Related Adrenal Diseases*, 1937. London: Ballière, Tindall & Cox.
[15] SLOT, W. J. B., *Acta med. Scand.*, 1936, lxxxix, 371.
[16] SIMPSON, S. L., and JOLL, C. A., *Endocrinology*, 1938, xxii, 595.
[17] KEPLER, E. J., *Proc. Staff Meet. Mayo Clinic*, 1938, xiii, No. 23, 353.
[18] LEWIS, DEAN, and GESCHICKTER, C. F., "Demonstration of Hormones in Tumours", *Ann. of Surg.*, 1936, civ, 787.

SHORT NOTES OF RARE OR OBSCURE CASES

LEIOMYOMA OF THE STOMACH

By Sir GIRLING BALL

This is a rare condition worth recording.

History.—F. B., male, aged 65, entered the Royal Masonic Hospital, London, on December 7, 1937, giving a history of feeling out-of-sorts for a year, although there were no particular symptoms to indicate the cause.

Seven weeks before admission to hospital he had had a severe hæmatemesis, followed first by melæna and then by a more serious bleeding which caused him to collapse. After the second attack the melæna persisted for fourteen days.

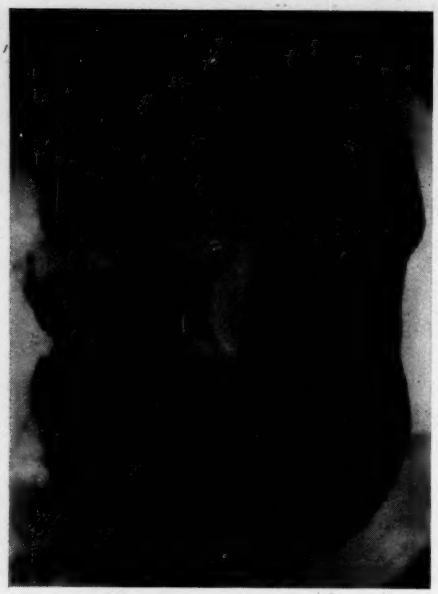


Fig. 663.—Radiograph showing the defect along the lesser curvature of the stomach.

The bleeding was unaccompanied by any other symptoms, nor had there been any gastric symptoms previously; in fact, apart from enteric fever in January, 1936, he had had a perfectly healthy life. He had, however, lost a stone in weight during the previous four months.

The patient was placed on a rigorous diet, to which he had adhered, and there had not been a further recurrence of the bleeding.

On Examination.—He was very pale, but otherwise there were no physical signs. A barium meal radiograph demonstrated a defect along the lesser curvature of the stomach, high up, the irregularity of which led to the suspicion that a somewhat extensive carcinoma was present (*Fig.* 663). It was decided to explore the abdomen to discover the nature of the lesion and, if possible, to remove it.

At Operation.—Through a left supra-umbilical paramedian incision the stomach was examined. Towards the cardiac end of the stomach, high up on the lesser curvature, a swelling could be felt, growing into the lumen of the viscus. It was firm and rounded, apparently involving the whole thickness of the stomach wall, but in no way extending through it or adherent to surrounding structures. There was no enlargement of lymphatic glands or secondary deposit in the liver. The stomach was quite easily drawn on to the abdominal wall. The lump was regarded as being an early carcinoma. It was decided to perform a partial

gastrectomy. Under intratracheal gas, oxygen, and ether anæsthesia, more than two-thirds of the stomach was removed. A modified Polya-Moynihan operation was performed.

SUBSEQUENT PROGRESS.—The patient left the hospital three weeks later after an uninterrupted recovery, and at the end of fifteen months reported himself as being in perfect health.

PATHOLOGICAL.—The portion of stomach removed is illustrated in the accompanying drawing (*Fig.* 664). The stomach is split open along the greater curvature.

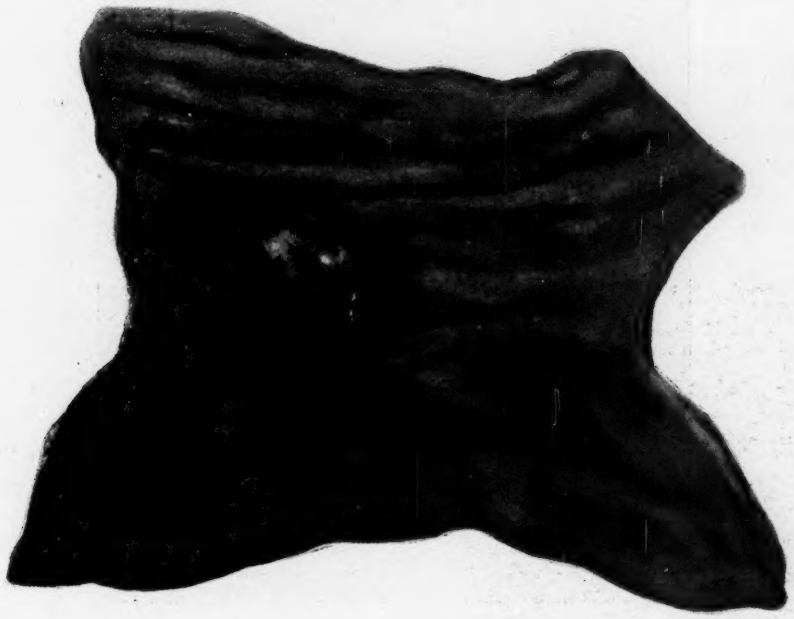


FIG. 664.—Drawing of the portion of stomach removed, showing the tumour on the lesser curvature and the normal condition of all the mucosa, except for the small hole in the portion covering the tumour.

On the lesser curvature is a large sessile circumscribed tumour, measuring 4·5 × 4·0 × 3·0 cm.; it is covered by mucosa, which is not ulcerated, although at one point a small hole is present, through which the blood apparently escaped. The mucosa of the rest of the stomach presents no abnormality. On the serous aspect there is no suggestion of infiltration. There are no enlarged lymphatic glands.

On cutting into the tumour the centre was found to consist of a cavity containing much blood, and a probe could be passed through the small hole on the surface into the cavity. The rest of the tumour was pinkish in colour and firm in consistency.

The microphotograph (*Fig.* 665) demonstrates that the tumour is composed of non-striped muscle-fibres arranged in whorls, the bundles being separated from one another by a small amount of loose connective tissue. Many areas show an advanced degree of hyaline degeneration.

The tumour is thus a leiomyoma and shows no evidence of malignant disease. Presumably, the advanced degree of hyaline degeneration accounts for the cystic area in the centre of the tumour, into which the hæmorrhage had occurred.

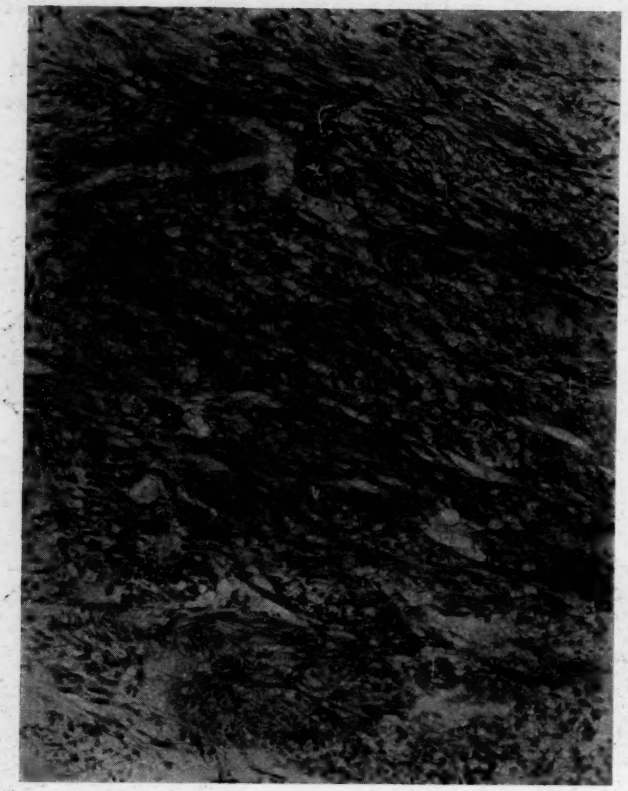


FIG. 665.—Microphotograph of section of the tumour showing its leiomyomatous structure.

A CASE OF SPONTANEOUS ABSORPTION OF BONE

BY W. A. JACKMAN, BRISTOL

THE following account of a case will, I think, prove the condition to be one of extreme rarity, and I venture to bring it to the notice of the medical profession in the hope that it will not only be of interest to many, but also that it will call forth some enlightenment as to the nature of this disease, and better still as to its treatment. If my hopes are thus fulfilled, it may enable me to save my patient's right hand, or for aught I know, the left as well.

On January 9, 1932, A. A., a groundsman, aged 21 years, presented himself at the out-patient department complaining that he felt a pain in the right hand, which he had first noticed two weeks previously, after chopping some wood.

My clinical examination revealed slight tenderness along the line of the middle metacarpal. There were no sensory, motor, or vascular changes.

Suspecting some chronic inflammatory disease of bone, I ordered a radiograph, and this revealed a remarkable narrowing of the shaft of the middle metacarpal bone (*Fig.* 666). The original radiograph having been lost, this figure has been reconstructed from a drawing.

I advised a period of rest, and to attain this object I put the hand in a plaster-of-Paris splint. At the same time I explained to my patient the unusual nature of his disability and advised his regular attendance, but he did not return until October 8, 1936. He then complained of a deformity of his right hand, and this

FIG. 666.—Reconstructed photograph showing the appearance of the middle metacarpal when first X-rayed (January 9, 1932).

FIG. 667.—Photograph of the hands taken October 28, 1936. The middle finger of the right was useless in this situation.

he most certainly had (*Fig.* 667). The middle finger had ascended and its base was wedged between the heads of the adjacent metacarpals; it was useless and hampered the movements of the second fingers on either side. A radiograph (*Fig.* 668) at this time revealed an almost complete absence of the middle metacarpal and a patchy erosion of the os magnum, giving it a moth-eaten appearance.

I amputated the middle finger on October 20, 1936, and removed the os magnum at the same time. Dr. A. D. Fraser, Honorary Pathologist to the Bristol Royal Infirmary, examined this bone and reported that of the known diseases of bone it conformed most nearly to fibrocystic disease. The phalanges were normal.

The incision healed well, without complication, and the man returned to work about a month later, and has been at work ever since. He has regularly attended my clinic and has been taking calcium albuminate and vitamin A and D up to the present time, though his blood-calcium is normal.

FIG. 668.—Radiograph of right hand taken October 28, 1936. Note complete absorption of third metacarpal, with the exception of a small flake at the head.

FIG. 669.—Radiograph of the right hand taken October 30, 1937. Note the commencing atrophy of the fourth metacarpal.

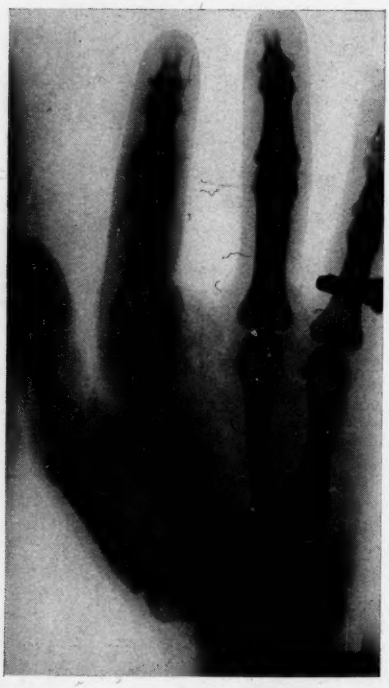


FIG. 670.—Radiograph taken November 10, 1938. Note the absorption of the fourth metacarpal.

My problem lies in the fact that serial radiographs demonstrate clearly that the fourth metacarpal of this same hand is about to imitate the behaviour of its neighbour (*Figs.* 669, 670).

He is a working man, living by his hands, so that naturally he is not willing to submit to a long period of rest unless I can offer reasonable hope of arresting the course of the disease by this method of treatment, and this I cannot do; neither do I believe in its efficacy in this case, for I feel sure that there is some process at work in this hand which mere inactivity will not arrest. The Wassermann and kindred reactions are negative, and this test has been carried out on several occasions, thus giving fairly definite contra-indication to antisyphilitic measures, and indeed this diagnosis presents itself to me more as a refuge of the destitute than on the basis of clinical evidence; neither does the history support this diagnosis.

The blood-calcium has been and is normal, and there is no generalized osseous change to suggest the presence of a parathyroid tumour, which would be unlikely to produce so localized and selective a bony lesion.

In February, 1934, E. Maurice Smith[1] described familial neurotrophic osseous atrophy, with anæsthesia and loss of bone, observed in two generations of a family and by the history in three generations. In this series syphilis, tuberculosis, and syringomyelia were eliminated, but leprosy was not excluded. These cases differed from that described here in the following points: (1) The feet only were affected; (2) There was associated ulceration; (3) There were sensory nerve changes; (4) A very definite family history obtained.

It seems, then, that except on the common ground of bone atrophy, the conditions are hardly comparable, and must differ in their pathogeny and pathology. Yet I feel bound to quote Mr. Smith's paper in relation to my description of this condition, as being the only published work available to me which sets forth any kind of sign or symptom bearing comparison to the disease from which my patient suffers.

I should like to thank Mr. Hey Groves for the interest he has taken in this case and for his help in the preparation for its publication.

REFERENCE

[1] SMITH, E. MAURICE, *Jour. Amer. Med. Assoc.*, 1934, cii, Feb. 24, 593.

A CASE OF CONGENITAL RANULA OF THE LEFT SUBMAXILLARY GLAND

BY M. G. KINI

SURGEON, KING GEORGE HOSPITAL, VIZAGAPATAM (S. INDIA)

CONGENITAL ranulas are rare. Muller, in his paper read before the Moscow Medical Society, found only 5 cases of congenital ranula in 80,000 children examined in the Moscow Foundling Hospital. In the literature only 20 cases have so far been reported (Fitzwilliams). The following case of a congenital ranula is therefore of interest.

HISTORY.—The patient was a woman, aged 20 years. She was admitted in 1933 for a swelling of the tongue protruding out of the mouth (*Fig.* 671). This

complaint started in her childhood as a small tumour the size of a pea on the inferior aspect of the tongue, and grew gradually and painlessly to the size of a closed fist.

On Examination.—The mouth was found to be constantly open on account of the enormous size of the swelling. Most of the tumour was in the inferior aspect of the tongue, over which the tongue was spread out, causing thinning of the organ. The dorsum of the tongue was pale, dry, rough, and scaly, being constantly outside the mouth. Saliva was constantly dribbling from the mouth, from the inferior aspect of the tongue. There was difficulty in speech and deglutition, and the lower set of teeth were everted and loose; pyorrhœa was present. She was a fairly well-nourished woman. Her heart and lungs were normal; in both eyes there was staphyloma, the result of old corneal ulcers. Blood Wassermann was negative. Blood-pressure was 115/90 mm. Hg. The urine was normal.

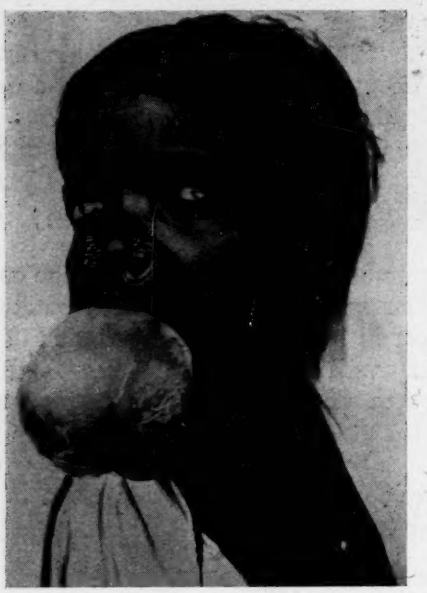


Fig. 671.—Photograph showing the swelling protruding from the mouth.

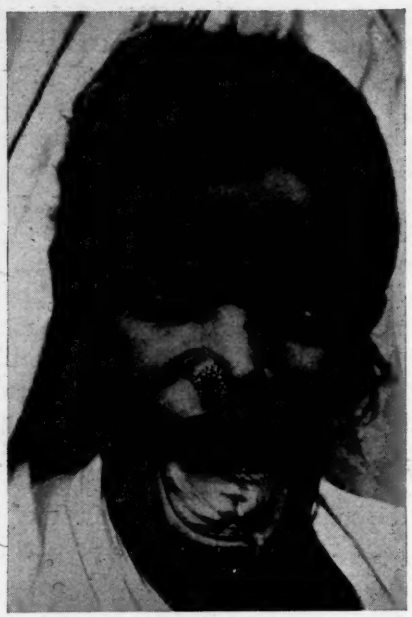


Fig. 672.—The patient at the time of discharge. She was unable to close her mouth owing to the changes which had taken place in the lower jaw.

At Operation.—After preliminary removal of the loose teeth, the patient was operated upon under general anæsthesia. The whole of the cystic swelling, with a wedge-shaped bit of the tongue, was enucleated and the tongue and floor of the mouth were carefully sutured and drained. There was slight sepsis underneath the tongue, which cleared up with the ordinary treatment.

The patient was discharged on July 29, 1933. (*Fig.* 672.)

The Specimen.—The biochemical report showed that the fluid contained a starch-splitting enzyme in fair concentration. The pathological report showed that the inner wall of the cyst was lined by columnar epithelium and in places by cubical epithelium, which was heaped up in a number of layers in some parts of the section. A smear of the fluid showed degenerating cells and staphylococci.

X-ray examination of the jaw after operation showed an unerupted right lower premolar. The width of the lower jaw was found to be very small. A large groove was present in the body of the lower jaw, with marked obliquity of the angle of the edentulous jaw. (*Fig.* 673.)

FIG. 673.—Radiograph of jaw after operation (*see text*).

Points of Interest.—

1. The cyst was of congenital origin.
2. The course of Wharton's duct could not be traced.
3. The biochemical report of the fluid from the cyst showed a starch-splitting enzyme in fair concentration. The cyst being in the situation of the submaxillary gland, this is a ranula arising from the submaxillary gland.
4. The lower jaw had undergone a change. The angle had become oblique, with the result that the patient was unable to close the mouth after removal of the tumour. This is an illustration of Wolff's law.

REVIEWS AND NOTICES OF BOOKS

Modern Surgical Technic. By MAX THOREK, M.D., K.L.H. (France), K.C. (Italy), Professor of Clinical Surgery, Cook County Graduate School of Medicine; Attending Surgeon, Cook County Hospital; Surgeon-in-Chief, The American Hospital; etc. In three volumes. 10¼ × 7 in. Pp. 2045 + xcvi, with 2174 illustrations. 1938. Philadelphia and London: J. B. Lippincott Co. £7 10s. net. Volumes not sold separately.

IT is a rare event nowadays for a text-book covering the whole field of surgical technique to be carried out by a single writer, and it was therefore with much interest that we took up this great book. A cursory glance through its pages further intrigued us by the great wealth of beautiful illustrations, most of which are by Mr. W. C. Shepard. But when we settled down to a detailed examination of chapter by chapter we were greatly disappointed to find that in all but the sections on abdominal surgery the book is not a well-balanced representation of modern methods.

The first volume deals with general principles, anæsthesia, the head and neck, and plastic surgery. The chapter on cranial surgery gives prominence to Jentzen's very complicated trephine, but other methods and instruments for opening the head are barely mentioned. Operations on the thyroid gland are well described and beautifully illustrated. There is a full account of Naffziger's operation for exophthalmos, but it would be more useful if it had some comment on its real value. The section on cleft palate might have been written in the early part of this century. Langenbeck, Berry, Legg, Brophy, and Davis Coley and their methods are fairly represented, but are we really to believe that these are still practised by the surgeons of Chicago? Plastic surgery, too, is very incomplete, as it gives no account of the tube pedicle method which is the very foundation of so much of modern plastic surgery.

The second volume deals with nerves, vessels, and bones. A bewildering number of operations on nerves are described and figured, including many—e.g., Foerster's division of posterior spinal roots and Royle's ramisection—which we thought were obsolete. Embolectomy is dismissed in a few lines with one illustration, although there is a whole chapter on pulmonary embolectomy. The section on bone and joint surgery is very unsatisfactory. The placing of wire sutures and plates and screws is dealt with, but the subject of bone-grafting is hardly mentioned. Arthrodesis is only described as done for the sacro-iliac joint. The modern treatment of fractured neck of the femur is not included, but there is a description of Barker's method of suturing a fractured patella, which we should have thought had only a historical interest.

The third volume deals with abdominal surgery, and here we feel that we are reading about the real work of the author. The chapters on the stomach and intestine are full, and, like the rest of the work, beautifully illustrated, though there are a bewildering number of methods to choose from. In describing Gallie's fascial sutures for repairing abdominal defects no mention is made of the fasciotome for cutting the grafts. The only operation for absence of the vagina described is that of Baldwin, in which the new passage is made from a double loop of ileum, and there is no criticism of this or mention of Gillie's method.

The paper, printing, and wealth of illustration are excellent.

Pye's Surgical Handicraft. A Manual of Surgical Manipulations, Minor Surgery, and Other Matters connected with the Work of House Surgeons and of Surgical Dressers. Edited by HAMILTON BAILEY, F.R.C.S. Eng., Surgeon, Royal Northern Hospital, London; Surgeon and Urologist, Essex County Council; Surgeon, Italian Hospital; etc. Eleventh edition. 8¾ × 5⅝ in. Pp. 512 + viii, with 375 illustrations, some coloured. 1939. Bristol: John Wright & Sons Ltd. 21s. net.

WALTER PYE (1853–92) had a short, but brilliant, career. A chance meeting with Manson in China turned his mind to medicine. He entered at St. Bartholomew's Hospital, qualified at the age of 23, and became house physician to Southey and house surgeon to Sir Wm. Savory.

He drew attention to himself by his early writing, and quickly secured posts at St. Mary's Hospital and the Royal College of Surgeons.

It is curious to note that of all his writings, which were many, the work that perpetuates his name is a students' handbook, *Pye's Surgical Handicraft*.

This present edition is the eleventh, the first having been published in 1884. No more need be said. Mr. Pye realized that the student and the resident demanded such a book to which he could turn in the thousand-and-one emergencies of daily work, and they still demand it. But one would like to see Mr. Pye's face if he could read his own book. He would not recognize it, for, in accordance with modern practice, it has been completely reconditioned.

The present edition has been revised and edited by Hamilton Bailey, with the assistance of twenty-eight collaborators, including twelve physicians and two members of the nursing profession. It deals with every practical problem with which the house surgeon may be concerned—from such a simple thing as tying up of a cut finger to the carrying out of such complicated procedures as a bronchography. The clear and well-chosen illustrations are very helpful to the understanding of the text.

Minor Medical Operations. For Senior Medical Students and Recently Qualified Practitioners. By KENNETH HARRIS, M.A., M.D. (Cantab.), F.R.C.P. (Lond.), Physician, University College Hospital; Physician, Royal Chest Hospital; and EDITH HARRIS, M.B., B.S. (Lond.), D.P.H. (Eng.), formerly Deputy Medical Officer of Health, Borough of Hornsey. $7\frac{1}{2} \times 5$ in. Pp. 198 + xii, with 41 illustrations. 1938. London: H. K. Lewis & Co. Ltd. 7s. 6d. net.

THIS is a very useful and clearly written guide-book. One hardly realizes until looking through a book of this sort how very many more or less complicated procedures may have to be undertaken by a resident medical officer or a nursing sister. A good many of these procedures are really carried out in the laboratories, such as the urea concentration test, and for this reason it is necessary to have various formulæ at one's disposal. It is sufficiently illustrated for all practical purposes, and we feel sure that it will prove of great value, both to residents and sisters in charge of the sick. It is very complete in its scope, including such simple things as hypodermic injections and such complicated things as bronchography after the injection of lipiodol and cisternal puncture.

Pratica Chirurgica. By VITTORIO PUCCINELLI. $9\frac{3}{4} \times 6\frac{3}{4}$ in. Pp. 707 + viii, with a number of illustrations. 1938. Bologna: L. Cappelli. L. 100.

THE publication of this work, which records the surgical activity of the author over many years, with the deductions of his experience, discloses an obscure quarrel that led to his rejection for an academic position, on the ground that he had "little aptitude for cultural work". Though 47 years of age, he "lacked true scientific preparation". Can it be that Fascist, like Nazi science, must be 'orthodox'? At any rate, this work, though addressed to fellow workers who may not be 'colti', is interesting, and relates to the results of more than 10,000 personal operations in the whole field of general surgery.

One chapter deals with the author's investigations into air-borne bacteria in theatres, wards, and casualty departments, and suggests that there is a considerable field for the lately proposed method of sterilizing the atmosphere and surfaces of rooms. The other chapters select for extended description the more exceptional cases in the various regions of the body that have occurred in the course of his experience. He is evidently well read in surgical literature.

Experience in the Management of Fractures and Dislocations. By the Staff of the Fracture Service, Massachusetts General Hospital, Boston. Under the general editorship of PHILIP D. WILSON, M.D., Surgeon-in-chief, Hospital for Ruptured and Crippled, New York; Clinical Professor of Orthopædic Surgery, College of Physicians and Surgeons, Columbia University, etc. $10\frac{1}{2} \times 7$ in. Pp. 1036 + viii, with 1419 illustrations. 1938. Philadelphia, London, Montreal: J. B. Lippincott Co. 65s. net.

THIS is a most unusual and quite unique book, because it is not only based on more than 4000 consecutive and unselected cases, but it actually gives the clinical history and results of nearly all of these.

It is written by twenty-three surgeons, all of whom are or have been in the fracture service of the Massachusetts General Hospital, including such well-known authorities as Smith-Petersen and Scudder.

The book consists of 34 chapters, the first 30 of which deal with the fractures in different regions, from the finger bones to the acetabulum. The last four chapters are on pathologic fractures, compound fractures, delayed union and non-union, and the treatment of recent fractures by operation. Each chapter consists in a description of the anatomy of the part and of the various methods used, with a summary of results. Then follows a list of all the fractures of the particular bone under consideration, with outline sketches of the radiographs before and after treatment, and the final result in each case. The results are represented by a very convenient formula of the three letters A, F, and E, standing for anatomy, function, and economic result, each letter being followed by a numeral from 0 to 4. The numeral 4 representing a perfect result and the others ¾, ½, ¼, or zero of perfection. This formula is so convenient as to invite universal adoption.

One of the outstanding features of the book is its frank honesty. The authors are so critical of their own results that they disarm any hostile criticism. For instance, in speaking of fractures of the shaft of the femur it is admitted that the end-results of open operation have not been satisfactory and that the methods of traction have not been efficient (p. 772). The unsatisfactory results are attributed to a lack of uniformity of control and technique.

We consider that in its wealth of detail and masterly arrangement the treatise is of inestimable value. To every one who is interested in fracture treatment it should be a source of great delight, because if he has not done so well himself he can learn how to do better, and if he has done better he can rejoice in his superior methods and ability. But we venture to assert without fear of contradiction that no worker or writer on the subject can afford to speak lightly of this book unless he is prepared to put forward an equally complete and candid exposition of his own work.

Technik der Knockenbruchbehandlung. By Dr. LORENZ BÖHLER, Director of the Accident Hospital and Professor of Surgery in the University of Vienna. Sixth edition, in two volumes. Pp. 1532, with 3054 figures. Vienna : Wilhelm Maudrich. RM. 100.

THE surgical world is so much indebted to Professor Böhler for his pioneer work on fractures and the clear and dogmatic exposition of his principles, that it will welcome this new edition of his great work.

We confess we are rather alarmed at the bulk the book has reached and are disappointed to find that its interest has not been proportionately increased. Roughly it has double the number of pages and three times the number of illustrations. This may increase its value as a book of reference, but it makes it more difficult to follow as a teaching text-book. The general principles of treatment remain unchanged, but in their exposition there is a great deal of rather tedious repetition. Böhler remains an opponent of most modern methods of open operative treatment, and we think that his method of representing these by picking out extreme examples of operative failures is very unfair. It would be quite easy to misrepresent Böhler's methods by quoting and illustrating examples of disaster which have followed their misuse. Methods of bone-grafting are very briefly and inadequately described.

The chapters on fractures of the spine are excellent, with a great wealth of illustration. The rare forms of fracture-dislocation in which the articular processes are displaced and impacted are fully dealt with. New methods of dealing with stiff fingers are included.

In the second volume there are new observations of the late complications of dislocation of the hip. The account of the treatment of fracture of the neck of the femur is very remarkable. The operation is said to occupy from one to two hours and is done through a large incision, which is drained. It is admitted that it is unsuitable for very ill or feeble patients, and there is an imposing list of no less than fifty-five mistakes which may be made in its performance !

There is a good chapter on the organization of treatment of war fractures, emphasizing the importance of continuity of control.

In conclusion, whilst heartily congratulating the author upon his painstaking and monumental work, we cannot refrain from expressing the hope that it may be edited and abridged so that sound and essential principles may not be so buried in the excess of descriptive details and repetitions.

Fractures of the Jaws. By ROBERT H. IVY, M.D., D.D.S., F.A.C.S., Professor of Maxillo-facial Surgery, University of Pennsylvania, etc.; and LAWRENCE CURTIS, A.B., M.D., D.D.S., F.A.C.S., Assistant Professor of Maxillo-facial Surgery, University of Pennsylvania, etc. Second edition, thoroughly revised. 9½ × 6¼ in. Pp. 192, with 199 illustrations. 1938. London: Henry Kimpton. 21s. net.

THIS book is now the recognized text-book on the subject of fractures of the jaws, and it is gratifying to welcome a second edition. The text follows very closely on that of the first edition, with an additional chapter on fractures of the nasal bones.

The preface to this edition again emphasizes that the procedures recommended can be undertaken by the general surgeon and the maxillo-facial specialist without resort to complicated dental appliances.

The authors' choice of method of fixation for fractured jaws is by interdental wiring, as against the metal-cap splint, and the reason for this preference is realized when it is noted that the book deals largely with simple fractures rather than with more complicated fractures with comminution or loss of bone. This omission to enlarge upon the treatment of complicated fractures is a little surprising, as in Chapter 4 the subject of bone-grafting is adequately dealt with.

The first two chapters deal with anatomical and general considerations of fractures, whilst in Chapter 3 head bandages are described, and valuable advice is given in emphasizing the necessity of passing the bandage beneath the chin instead of in front, as is so often done, thus preventing the backward displacement from being accentuated in certain types of fractures. This chapter also contains an excellent description of eyelet wiring, followed by an account of the various types of fractures and their treatment. In dealing with fractures of the neck of the condyle the authors are to be commended for declaring against the open operation method for these cases, but at the same time it is somewhat surprising to note the recommendation of the immobilization of the upper and lower teeth for a period of three to five weeks, whereas if a metal-cap splint with a vertical flange is fitted to the lower jaw the period of immobilization need only be from three to five days.

In dealing with anæsthesia the authors adhere to their preference for fixation without general anæsthesia, mentioning as their third objection that post-anæsthetic vomiting may give rise to asphyxiation if the maxilla and mandible are wired together. In practice this belief appears to be a fallacy, and, furthermore, any respiratory obstruction may be avoided by inserting a stout suture through the tongue before fixation of the jaws.

Chapter 7 gives an excellent description of roentgenographic technique, the extra-oral and intra-oral techniques being fully explained.

The chapter contributed by Clyde W. Scogin, D.D.S., on dietary management contains very valuable advice on this important subject, and should prove of considerable assistance in maintaining properly balanced and varied diets.

The high standard of illustrations is fully maintained in this edition, and the authors are to be congratulated for, as mentioned in the preface, contributing so successfully towards improvement in the treatment of these cases, and giving such excellent aid to all surgeons and dental surgeons called upon to deal with fractures of the jaws.

Röntgendiagnostik der Gelenke mittels Doppelkontrastmethode. By Dr. J. OBERHOLZER. With a Foreword by Dr. med. E. BIRCHER. Vol. 56 of *Fortschritte auf dem Gebiete der Röntgenstrahlen.* 12 × 8½ in. Pp. 128, with 134 illustrations. 1938. Leipzig: Georg Thieme. RM. 23; bound, RM. 25.

FOR many years endeavours have been made to see into the interior of the larger joints by means of various modifications of X-ray technique. In 1914 gas (oxygen, nitrogen, or air) was injected into the joint cavity so as to provide a light background for the denser contents. In 1930 various opaque substances containing iodine were used to give a dark outline of the joint recesses. In 1932 Dr. Bircher, who writes a preface to this book, used a combination of both methods so as to obtain the maximum degree of shadow contrast.

The filling of the joint is done on the X-ray table. After sterilizing and anæsthetizing the skin, oxygen is injected under a pressure of 120 c.c. of water. The gas is filtered and the pressure controlled by a manometer. Then through the same needle 2–3 c.c. of perabrodil is injected and the radiographs are taken.

A number of very good X-ray pictures are given of the results of this method of examination. These are of the knee, elbow, shoulder, and hip.

It is obvious that much experience will be needed in order to carry out this method, and still more to interpret its results. In gross lesions, e.g., loose bodies in the joint, the condition might be recognized by plain radiographs, whereas in obscure lesions, e.g., rupture of the menisci, it is very difficult to read the details of the radiograph given by this elaborate method.

Röntgendiagnostik der Knochen- und Gelenkkrankheiten. By Professor Dr. ROBERT KIENBÖCK, Vienna. H. 5, *Rheumatoide Gelenkstuberkulose.* 10½ × 7½ in. Pp. 451–1049, with 610 illustrations. 1938. Berlin and Vienna: Urban & Schwarzenberg. RM. 60.

THIS is the fifth volume of a series dealing with the X-ray aspects of bone and joint disease. It consists chiefly in the clinical and radiographic reports of 378 cases, each of which is briefly described and a number of radiographs given. These are arranged in three main groups, viz., the rheumatoid type, the destructive type, and the synostotic type. Each of the two first groups is again subdivided into adult cases, adult cases in which the disease started in childhood, and cases in children. The last group, of chronic disease producing ankylosis, is chiefly concerned with senile kyphosis or Bechterew's disease. It is surprising that this is included among tuberculous diseases. Consisting as it does almost entirely of case reports, the book is rather for reference than perusal.

Chirurgie der Lungen und des Brustfelles. By ALFRED BRUNNER, Munich. Bd. 26 of *Medizinische Praxis* (Grote, Fromme, and Warnekros). 8¾ × 6 in. Pp. 282 + xii, with 112 illustrations. 1938. Dresden and Leipzig: Theodor Steinkopff. RM. 22.50; bound, RM. 27.

THE high standard set by former contributors to the series *Medizinische Praxis* makes the lot of any new author an unenviable one. *Chirurgie der Lungen und des Brustfelles* is, however, a worthy successor, and makes a useful addition to contemporary literature in that it is based on the experience and practice of Dr. Alfred Brunner. The opinions and impressions expressed have a decided personal character even though they are coloured by the teachings of Professor Sauerbruch, to whom Dr. Brunner was an assistant for many years.

In a book of limited size it is clearly impossible to obtain an absolute balance in all aspects of the subject, and clinical descriptions suffer in this respect by comparison with operative treatment. The proportions of the chapters on individual conditions are well maintained, though there is undue brevity in considering malignant disease of the lung.

Practically all works from Central Europe lay considerable emphasis on the value of *plombierung* in various departments of chest surgery. The procedure consists of making an extrapleural bed for the paraffin-wax filling or *plombe* which is placed over a lung abscess or tuberculous cavity—in the former instance to promote adhesions and possibly drainage, and in the latter to produce a localized collapse. It would be both interesting and instructive to know why the popularity of this operation is maintained in some clinics, while its employment in English-speaking countries is practically unknown. Actually the term *plombierung* has found no translation into this tongue unless it be the scarcely more satisfactory 'plombage'.

The indications for the various operations used in phthisis are discussed in a reasoned and comprehensive manner. It is not to be expected that these views will meet with universal agreement in a subject as complex as this, but the exposition is clear and free from confusion. The only point that could reasonably be criticized is one that is common to most works in German on this subject, and that is the unnecessary and rather arbitrary distinction between different types of thoracoplasty. The actual extent of the thoracoplastic operations in this work is illustrated by photographs of the actual ribs removed alongside the relevant X-ray reproductions. Here it may be noted that whereas long lengths of rib are often removed, the resection is not always carried back to the level of the transverse process, as is the custom in this country.

The production of the book is good, though possibly the illustrations, which consist largely of radiographs, would have benefited by being on a slightly larger scale. One of the great values of a work of this type is that it gives a clear expression of the procedures and views on chest surgery that are held by an acknowledged authority, so that by comparison and contrast with practice elsewhere we may approach a solution to some of the more difficult problems that this specialized branch of surgery sets.

Die Anatomie der Pleurakuppel. Ein anatomischer Beitrag zur Thoraxchirurgie. By ANTON HAFFERL, Graz. 10 × 6¾ in. Pp. 90, with 21 coloured illustrations. 1939. Berlin: Julius Springer. RM. 12.

PROFESSOR Hafferl has written a detailed topographical anatomy of the structures lying in relation to the pleural dome. The first part of the monograph consists of a systematic description of the skeletal parts, blood-vessels, nerves, and fascia. This is followed by a section on the various surgical approaches to the lung apex. The author has provided excellent illustrations in colour, which will be of value to those who contemplate surgical procedures in the regions described. A bibliography, which includes not only purely anatomical papers but also surgical literature, and a brief index increase the usefulness of the monograph.

Tumori del Rene. By MARIO PIGNALOSA and MARIO FERNANDEZ, Urological Clinic, University of Milan. 9¾ × 6¾ in. Pp. 193, with 30 illustrations in the text and 5 coloured plates. 1938. Bologna: L. Cappelli. L. 35.

THIS little monograph is based on more than a hundred cases from the clinic of Professor Lasio in Milan. There is a good deal of historical introduction, some unnecessary discussion of possible causes of cancer, and a very long account of all the opinions offered about the question of the origin of hypernephromata in the past fifty years.

It cannot be said that anything very definite emerges, and the authors have a preference for the term "atypical carcinoma", which begs the question. The most interesting part of the study is that of pyelographic pictures, which demonstrate how comparatively slight may be the deviation from normal, even with a sizeable tumour. The discussion on the irradiation treatment of the carcinomata asserts, as has been done often of late, that there is serious danger of enhancing the rate of growth and determining metastases. Here, as elsewhere, it means that where massive unfractionated dosage is employed, the general state of the patient is so gravely impaired that the common terminal downward rush, seen also in the unirradiated, is anticipated. It is admitted that, even properly administered, irradiation has so far little success to boast of in the cure of these neoplasms.

On the Cause of Gastric Ulcers. An Experimental Study. By Dr. R. BRUMMELKAMP. In English. 9¾ × 6¼ in. Pp. 86, with 39 illustrations, most of which are plates. 1938. Amsterdam: N. V. Noord-Hollandsche Uitgeversmaatschappij. Fl. 3.50.

THE author has carried out an extensive series of experiments in animals which have led him to the conclusion that free acid in the stomach contents is capable, under certain conditions, of producing ulceration in the normal gastric mucosa. He is of the opinion that these ulcers are of a type comparable to those found in man. The "certain conditions" which the author considers as being necessary are those which lead to the presence of an active gastric juice with free acid in an empty stomach. He suggests in his conclusions that "over-stimulation of the vagus nerve" may be one of the factors responsible for the secretion of free acid. This has been proved by many investigators in this country, but no reference is made to such work. While the author has established conclusively in animals that free hydrochloric acid in a resting stomach is the immediate causal factor in peptic ulceration, much remains to be done to determine the organic and psychic causes leading to hypersecretion.

Pathologische Physiologie chirurgischer Erkrankungen (Experimentelle Chirurgie) (Franz Rost). Fourth edition. Part I. By F. K. KESSEL, F. MERKE, and F. MEYTHALER, edited by TH. NAEGELI. 10 × 6⅝ in. Pp. 375 + viii. 1938. Berlin: Julius Springer. RM. 30.00; bound, RM. 31.50.

IT is more than thirteen years ago that the third edition of this work appeared. The preparation of the first volume of the present edition was interrupted by the death of Professor Franz Rost in 1935, in the midst of sifting the voluminous literature which had gathered in the intervening years. Prof. T. Naegeli, who assumed the task, has written the sections on the alimentary tract and spleen, and Dr. Meythaler those on the pancreas, liver, and biliary system. The book sets forth clearly, concisely, and impartially the present-day conceptions of the pathological

physiology of the surgical diseases of these organs. The exhaustive and up-to-date bibliographies after each section show that the immense labour of reading the great amount of work produced since 1925 has been well done. In many instances papers published in the early part of 1938 are mentioned, but, as might be expected, several well-known papers are missing. The value of the bibliographies, is, however, diminished because the titles of the papers listed are not given. The sections on the alimentary tract and liver are especially good, but that on diabetes omits the recent important work of Young. The book is valuable for reference, and should prove useful to those engaged in experimental surgical research.

A Cerebral Atlas. By RICHARD J. A. BERRY, M.D., F.R.S.E., F.R.C.S.E., Director of Medical Services to the Incorporation of National Institutions for Persons Requiring Care and Control, Stoke Park Colony, Bristol; etc. 18½ × 15½ in. Pp. 425, with 430 photographs. 1938. London: Oxford University Press Ltd. £5 5s. net.

THE National Institutions for Persons Requiring Care and Control were founded by the Rev. Harold Nelson Burden and the late Mrs. Katherine Mary Burden. The Burden Mental Research Trust was founded by Mrs. R. G. Burden, by the donation of £10,000 to be devoted to the elucidation of problems underlying the causation and inheritance of normal and abnormal mentality. This monumental work is one of the outcomes of the bequest.

It consists for the most part of full-sized photographs of the medial and lateral aspects of the cerebral hemispheres of defective brains, with similar views of a normal brain of approximately the same age. The defective brains were taken from 120 consecutive autopsies at Stoke Park Colony, and they are arranged in order of age. The normal brains were provided from the autopsies of general hospitals, where, in the absence of anything known to the contrary, the patient was assumed to have been of normal mentality. It is interesting to note that one such 'normal' brain proved to be so abnormal that inquiries were made as to the history of the boy whose brain it was. And it was found from his schoolmaster that it was being seriously considered whether the boy ought not to have been certified as a mental defective, before his death.

In the most general terms the defective brain shows less size, weight, and cortical area, than the normal brain of a patient of the same age. In a few cases there was a partial or complete absence of the corpus callosum; in many cases the area occupied by the frontal lobe was relatively small.

Each set of plates is followed by a short description of the defective brain, the details of its weight and measurements, percentage of precentral cortex, the clinical history and parentage, and cause of death of the patient. There are also thirteen microphotographs of portions of the cerebral cortex compared with similar preparations from normal brains. These microphotographs illustrate the neuronal abnormalities commonly found in some 80 per cent of defective's brains of no particular pathological type, namely, irregular alinement, abnormally small size, paucity per microscopic field, and, most characteristic of all, a crowding together of small nerve-cells in marked contrast to the well-spaced-out appearance of the normal adult supragranular cortex. In the remaining 20 per cent there was some gross pathological change, e.g., teratological deformity, sclerosis, microgyria, four-layered cortex, etc.

All the brains, both defective and normal, which are described, have been preserved and can be studied by those interested. We hope that some day they may be placed in some national museum.

It is difficult to express adequately our sense of admiration for this magnificent work, which reflects great credit alike on the far-sighted philanthropy of its originator and the energy and enthusiasm of its author and his assistants. It was a happy fate which brought Professor Berry to this country on his retirement from his academic chair in Australia, and which placed his special gifts at the service of neurological science in this country. At a time when most men in his position would have been content to retire to an arm-chair existence, Dr. Berry has undertaken a Herculean task and inspired and guided a number of assistants in the share of the work.

Our only grumble about the book is its enormous size and weight. If the author has no use for an arm-chair himself, he is evidently determined that his readers shall not use one either.

Meningiomas. Their Classification, Regional Behaviour, Life History, and Surgical End Results. By HARVEY CUSHING, M.D., with the collaboration of LOUISE EISENHARDT, M.D. 10 × 6¾ in. Pp. 785 + xiv, with 685 illustrations. 1938. Springfield, Ill., and Baltimore, Md.: Charles C. Thomas. $15.00.

THIS large volume consists of a minute survey of the clinical and pathological data derived from a study of no less than 313 meningiomas. This is the largest series of cases that has ever been reported, and every case has been histologically verified.

Although having certain common situations for their development, meningiomas may occur in the cavum Meckelii and produce the gassero-petrosal syndrome, while others may develop in the sheath of Schwalbe and cause exophthalmos and optic atrophy. Multiple meningiomas are also described and illustrated.

This book is an example of the value of careful clinical records, together with detailed X-ray pictures and visual charts. There are numerous clinical and pathological photographs interspersed with drawings made during the actual operation, showing the difficulties which may be encountered with this or that surgical approach.

Surgeons the world over are familiar with Harvey Cushing's writings and published works, but he has saved his *magnum opus* until now, for which we are very grateful to him.

The meningiomas are common tumours and for the most part are innocent in nature, so that good results follow their removal. However, they are very vascular, and it is because of this that the operative mortality has been high in the past; but now, owing to Cushing's technique and advice, the mortality has been reduced to a very low figure.

The book is excellently produced, and the special finish and colour tone of the paper brings out the illustrations with great clarity.

A Textbook of Neuro-radiology. By CECIL P. G. WAKELEY, D.Sc., F.R.C.S., F.R.S.E., F.A.C.S., F.R.A.C.S. (Hon.), Fellow of King's College, London; Senior Surgeon, King's College Hospital and West End Hospital for Nervous Diseases; etc.; and ALEXANDER ORLEY, M.D., D.M.R.E., Radiologist, West End Hospital for Nervous Diseases; etc. 10¼ × 6¾. Pp. 336 + xiv, with 229 illustrations. 1938. London: Baillière, Tindall & Cox. 25s. net.

THE outstanding progress which neurosurgery has made in recent years, its high degree of specialization, and its tendency to be concentrated in a few centres, have created a difficulty for many radiologists, who feel a natural diffidence when faced with a neurosurgical problem outside their experience. A work such as this, by a surgeon and a radiologist in collaboration, is sure of a welcome, since it enables any radiologist to make contact with this branch of the work, and to comprehend its salient features.

The authors appear to have aimed at a limited objective: the book consists largely of material derived from articles by recognized authorities which are to be found scattered through the world literature; the more important, as well as many of the rare, radiological findings have thus been collected. There are few important omissions, and few errors. The bibliography is extensive, but not always judiciously selected: it shows an undue leaning towards Continental literature, and overlooks some important work published in this country. It is doubtful whether the inclusion of ventriculography by means of lipiodol is worth while, except as a matter of historic interest. The uses of encephalography as an alternative to ventriculography, and its special indications in tumour diagnosis, call for greater emphasis. The descriptions of sellar changes due to hydrocephalus are open to criticism; as also is the statement that aneurysms of the circle of Willis enlarge the optic foramina. The orbital changes due to aneurysm have been the subject of recent papers which have not been referred to by the authors.

The work would, perhaps, have gained by the introduction of a preliminary chapter defining the true place of radiology in neurology, and its value in relation to other tests. Nevertheless, a wide field has been covered, and the authors are to be congratulated upon their success in compressing so much information into a book of this size. The notes on special techniques, the tables of differential diagnosis (after Pendergrass and de Lorimier), and the description of the pathological types of intracranial tumour will be found especially useful by the student. The line diagrams are well selected and clear, and often bring out the authors' points better than reproductions of skull radiographs could do.

In this book one is conscious of a certain lack of light and shade, of emphasis upon the relative importance of things, and of guidance based upon personal experience and personal view-points. This is felt especially in the chapter on ventriculography. Here the authors have closely followed a competent authority (Lysholm), but the inexperienced reader might easily conclude that by merely following certain recipes he would automatically obtain the desired results, which is far from being true in actual practice. This 'cut-and-dried' presentation prevails throughout the work; and is not quite in keeping with the critical, wary, and essentially sensitive approach to a neurological problem which is characteristic of modern clinical methods. Nevertheless, the volume, the first of its kind to be published in this country, will be welcomed as a useful introduction to the subject by radiologists and by others who are making a special study of neurology.

Diagnostic Roentgenology. Edited by ROSS GOLDEN, M.D., Professor of Radiology, the College of Physicians and Surgeons, Columbia University, etc. 9½ × 7¼ in. 255 renewal pages containing 230 illustrations. 1938. New York: Thomas Nelson & Sons. $4.50.

THIS is really an addition to the 1936 edition, which we reviewed in July of that year. As its name implies, it consists of a number of loose leaves which can be inserted into the spring-clip binding of the original volume. The present edition contains three completely new chapters: 'Dental Roentgenology', by Dr. Leroy M. Ennis; 'Soft Tissues of the Air and Food Passages of the Neck', by Dr. Barton R. Young; and 'The Abdomen', by Dr. Ross Golden. There is also a revised and enlarged index and table of contents.

This work, which aims at really keeping up to date, is much more than a mere atlas of radiographs. Each article discusses the morbid condition figured and there is a wonderfully complete list of references at the end of each chapter. There is so much of merit in these 255 pages that we must be content to note only a few points. The bone changes in caisson disease are more completely described and illustrated than we have ever seen before. There are some remarkable X-ray pictures of the biliary tracts, one of which was obtained by injecting lipiodol through a tube into the common bile-duct. The section on obstetrics gives many new views, one of which is a demonstration of placenta prævia. We are convinced by reading this work that roentgenology is the most rapidly expanding branch of medical science and one in which it is most important to keep up to date. But we feel that the loose leaf system in itself requires some education in modern business methods.

BOOK NOTICES

[The Editorial Committee acknowledge with thanks the receipt of the following volumes. A selection will be made from these for review, precedence being given to new books and to those having the greatest interest for our readers.]

Petite Chirurgie et Technique médicale courante. By G. ROUX. 9½ × 6¼ in. Pp. 591 + vi, with 361 illustrations. 1938. Paris: Masson et Cie. Fr. 90; bound Fr. 120.

Le Traitement non sanglant des Fractures du Rachis. By PIERRE MALLET-GUY, Paris. With a Preface by Professor R. LERICHE. 9¾ × 6½ in. Pp. 118 + vi, with 54 illustrations. 1938. Paris: Masson et Cie. Fr. 40.

Chirurgie de la Main. I. Livre du Praticien: Plaies, Infections et Traumatismes fermés de la Main. By MARC ISELIN, Surgeon to the American Hospital. 10 × 6¼ in. Pp. 320, with 135 illustrations. 1938. Paris: Masson et Cie. Fr. 65.

The Student's Handbook of Surgical Operations. By Sir FREDERICK TREVES, Bart., G.C.V.O., C.B., LL.D., F.R.C.S. Sixth edition, revised by CECIL P. G. WAKELEY, D.Sc., F.R.C.S. Eng., F.R.S. Edin., F.A.C.S., F.R.A.C.S., Senior Surgeon to King's College Hospital; Director of Surgical Studies and Teacher of Operative Surgery, King's College Hospital Medical School; etc. 7¼ × 4⅝ in. Pp. 563 + xii, with 246 illustrations. 1939. London, Toronto, Melbourne, and Sydney: Cassell & Co. Ltd. 12s. net.

The Medical Press and Circular, 1839-1939. A Hundred Years in the Life of a Medical Journal. By ROBERT J. ROWLETTE, M.D., F.R.C.P.I. 10 × 7½ in. Pp. 127 + x, with 10 plates. 1939. The Medical Press and Circular.

Cranio-cerebral Injuries: Their Diagnosis and Treatment. By DONALD MUNRO, A.B., M.D., F.A.C.S., Surgeon in Chief for Neurological Surgery at the Boston City Hospital; Assistant Professor of Neurological Surgery, The Medical School of Harvard University; etc. 8½ × 5⅝ in. Pp. 412 + xxvii, with 62 illustrations. 1939. London, New York, and Toronto: Oxford University Press. 21s. net.

Shock and Related Capillary Phenomena. By VIRGIL H. MOON, A.B., M.Sc., M.D., Professor of Pathology, Jefferson Medical College; etc. 8½ × 5⅝ in. Pp. 442 + xviii, with 30 illustrations. 1939. London, New York, and Toronto: Oxford University Press. 21s. net.

Unfall und Knochengeschwulst. By Doz. Dr. HANS HELLNER, Münster. Heft 25 of *Monatsschrift für Unfallheilkunde und Versicherungsmedizin* (zur Verth). 9½ × 6¼ in. Pp. 55, with 20 illustrations. 1939. Berlin: F. C. W. Vogel. RM. 4.80.

St. Thomas's Hospital Reports. Edited by Professor O. L. V. S. de WESSELOW and C. MAX PAGE, assisted by N. R. BARRETT, J. ST. C. ELKINGTON, and A. J. WRIGLEY. Second Series, Vol. III. Royal 8vo. Pp. 240, illustrated. St. Thomas's Hospital. 10s. (7s. 6d. to subscribers).

The Medical Press and Circular. Centenary Number, January 25, 1939. Pp. 65–126, with 28 pp. supplement on "Painful Conditions".

Treatment by Manipulation in General and Consulting Practice. By A. G. TIMBRELL FISHER, *M.C.*, M.B., Ch.B., F.R.C.S. Eng., Co-Trustee and Member of Executive and Research Advisory Committees of Empire Rheumatism Council; etc. Being the third edition of *Manipulative Surgery*. 8½ × 5⅜ in. Pp. 255 + xii, with 68 illustrations. 1939. London: H. K. Lewis & Co. Ltd. 12s. 6d. net.

Spinal Anæsthesia. By LOUIS H. MAXSON, A.B., M.D., Practising Specialist in Anæsthetics; former Chief Anæsthetist, Harborview (King County) Hospital, Seattle, Washington. Foreword by W. WAYNE BABCOCK, M.D., LL.D., F.A.C.S., Professor of Surgery, Temple University School of Medicine. 9 × 6 in. Pp. 409 + xxii, with 68 illustrations. 1939. Philadelphia and London: J. B. Lippincott Co. 30s. net.

The Functions of Human Voluntary Muscles. By NORMAN D. ROYLE, M.D., Ch.M., F.R.A.C.S., Honorary Demonstrator of Anatomy, University of Sydney; Senior Orthopædic Surgeon, Lewisham Hospital. 8½ × 5½ in. Pp. 42, with 11 illustrations. 1939. London and Sidney: Angus & Robertson Ltd. 3s. 6d.

The Surgery of Pain. By RENÉ LERICHE, M.D. Lyon, LL.D. Glasgow, F.R.C.S. Eng. Professor of Clinical Surgery, University of Strasbourg. Translated and edited by ARCHIBALD YOUNG, B.Sc., M.B., C.M., F.R.F.P.S.G., F.A.C.S., M.D. Strasbourg, Regius Professor of Surgery, University of Glasgow; Visiting Surgeon, Western Infirmary, Glasgow. 8½ × 5½ in. Pp. 512 + xx, with 18 illustrations. 1939. London: Baillière, Tindall & Cox. 21s. net.

Anatomy of the Human Lymphatic System. By H. ROUVIÈRE, Professor of Anatomy at the Medical Faculty of Paris, France. A compendium translated from the original *Anatomie des Lymphatiques de l'Homme* by M. J. TOBIAS, formerly of the Department of Anatomy, New York University. 10¾ × 8¼ in. Pp. 318 + ix, with 129 illustrations. 1938. Ann Arbor, Michigan: Edwards Bros. Inc. $4.00.

Treatment in General Practice. Vol. III. Anæsthesia: Surgery. Articles republished from the *British Medical Journal*. 8½ × 5½ in. Pp. 402 + xi, with 60 illustrations. 1939. London: H. K. Lewis & Co. Ltd. 10s. 6d. net.

Sir Thomas Roddick. His Work in Medicine and Public Life. By H. E. MACDERMOT, M.D. 8½ × 5½ in. Pp. 160 + xiv, with 12 illustrations. 1938. Toronto: The Macmillan Co. of Canada Ltd. 6s. 6d. net.

Surgeons All. By HARVEY GRAHAM. With a Foreword by OLIVER ST. JOHN GOGARTY. 9 × 6 in. Pp. 426, with 24 Plates. 1939. London: Rich & Cowan Ltd. 18s. net.

Surgical Treatment of Hand and Forearm Infections. By A. C. J. BRICKEL, A.B., M.D., Departments of Anatomy and Surgery, Western Reserve University. 10¼ × 6¾ in. Pp. 300, with 35 plates (10 coloured) and 166 text illustrations. 1939. London: Henry Kimpton. 31s. 6d. net.

Lehrbuch der Röntgendiagnostik. By H. R. SCHING, W. BAENSCH, and E. FRIEDL, and collaborators. Fourth edition. 11 × 7½ in. In 2 volumes. Pp. 2182 + xxxii, with 3658 illustrations and 13 plates. 1939. Leipzig: Georg Thieme. RM. 260; bound, RM. 270.

Infections of the Hand. A Guide to the Surgical Treatment of Acute and Chronic Suppurative Processes in the Fingers, Hand and Forearm. By ALLEN B. KANAVEL, M.D., Sc.D., Late Professor of Surgery, Northwestern University Medical School, Chicago; Attending Surgeon, Wesley Memorial and Passavant Memorial Hospitals, Chicago. Seventh edition. 9¼ × 5¾ in. Pp. 503, with 229 illustrations, many in colour. 1939. London: Baillière, Tindall & Cox. 30s. net.

Surgical Anatomy. By C. LATIMER CALLANDER, A.B., M.D., F.A.C.S., Associate Clinical Professor of Surgery and Topographical Anatomy, University of California Medical School. With a Foreword by DEAN LEWIS, M.D., Sc.D., LL.D., F.A.C.S. Second edition. 10¼ × 7¼ in. Pp. 858, with 819 illustrations. 1939. Philadelphia and London: W. B. Saunders Co. 45s. net.

Die Wintersportverletzungen. By Dr. MARCO PETITPIERRE, St. Moritz. 9¾ × 6¼ in. Pp. 194, with 197 illustrations, some coloured. 1939. Stuttgart: Ferdinand Enke. RM. 17; bound, RM. 18.60.

Fractures and Dislocations in General Practice. By JOHN HOSFORD, M.S. Lond., F.R.C.S.Eng., Assistant Surgeon to St. Bartholomew's Hospital; Late Hunterian Professor, Royal College of Surgeons. 8½ × 5½ in. Pp. 274 + viii, with 71 illustrations. 1939. London: H. K. Lewis & Co. Ltd. 12s. 6d.

A Manual of Fractures and Dislocations. By BARBARA BARTLETT STIMSON, A.B., M.D., Med.Sc.D., F.A.C.S., Associate in Surgery in the College of Physicians and Surgeons, Columbia University, New York City. 8 × 5½ in. Pp. 214, with 95 illustrations. 1939. London: Henry Kimpton. 12s. 6d. net.

Clinical Electrosurgery. By GUSTAVUS M. BLECH, G.C.S., G.C.G., M.D., LL.D. With chapters by HECTOR ALFRED COLWELL, M.B., Ph.D., M.R.C.P., and BRIAN WELLINGTON WINDEYER, M.B., B.S., F.R.C.S., D.M.R.E. 8¾ × 5¾ in. Pp. 389 + xxvii, with 34 illustrations. 1939. London: Oxford University Press. 21s. net.

Chirurgie und rheumatische Krankheiten. By Doz. Dr. A. FONIO, Bern. Bd. 14 of *Der Rheumatismus* (Jürgens). 8¾ × 5¾ in. Pp. 235 + xii, with 26 illustrations. 1939. Dresden and Leipzig: Theodor Steinkopff. RM. 11.25.

Recollections of Student Life and Later Days. By C. J. BOND, C.M.G., F.R.C.S., F.L.S. A Tribute to the Memory of the late Sir Victor Horsley, F.R.S. 8½ × 5½ in. Pp. 47. 1939. London: H. K. Lewis & Co. Ltd. 1s. net.

INDEX TO VOLUME XXVI

PAGE

ABDOMINAL injuries and their recipients - - - - 217
— operation for obturator hernia - 524
— wall, fibrosarcoma of, lymphatics in relation to - - - - - 493
Abscess(es) in acute infective osteomyelitis of spine - - - 79
— subphrenic, with tuberculosis of spleen (*see* Spleen)
Académie de Chirurgie de France, visit to Royal College of Surgeons of England - - - - - 240
Accessory thyroid, tumour of, with œsophageal polypus - - - 193
Acetabuloplasty for protrusio acetabuli 698
Acetabulum, adolescent deformities of (*see* Protrusio acetabuli)
Achalasis of cardia, nerve-supply of gastro-œsophageal junction in surgery of - - - - - 342
Acidogenic diet in treatment of recumbency calculi - - - - 108
Acidophil adenomata of pituitary (*see* Pituitary)
Acromegalism, visual impairment, and headache in acidophil pituitary adenomata - - - - - 908
Acromegaly (*see also* Pituitary Adenomata, Acidophil)
— 'fugitive' - - - - - - 814
Actinomyces bovis in ray fungus disease 33
Actinomycosis of breast, primary, case reports - - - - - 30, 32
— — — commentary - - - 33
— — — summary - - - - 34
Adamantinoma of tibia - - - 547
— — case report - - - - 547
— — summary - - - - - 553
Adenocarcinomata of pituitary (*see also* Pituitary Adenomata) - 915, 916
— rectum, lymphatics in relation to - 491
Adenoma, bronchial - - - - - 177
— pituitary (*see* Pituitary Adenomata)
— of stomach, case report - - 643
Adolescent deformities of acetabulum, protrusion (*see* Protrusio Acetabuli)
Adrenal cortex, surgery of - - - 925
— — — adrenogenital syndrome - 926
— — — discussion on biological aspects of sex hormones - - 939
— — — intersexuality - - - 934
— — — male hormone, biological tests for - - - - - - 932
— — — a new stain for virilism - 930
— — — psychological - - - 934

PAGE

Adrenal cortex, surgery of, treatment and results - - - - 937
Adrenogenital syndrome - - - 926
Age incidence in cancer of common bile-duct - - - - - 758
— — chromophobe adenoma of pituitary 862
— — obstructive jaundice - - - 394
— — obturator hernia - - - 522
— — sarcoma of intestine - - - 431
Aimim (betel nut) for dressing trephine wounds in Blanche Bay - - 7
AIRD, IAN: The behaviour of the blood-volume in intestinal obstruction and strangulation - - - 418
Albel's rings in radiological appearance of intracavernous carotid aneurysm - - - - - - 294
Aleppo, Altounyan Hospital, visit to 412
Alimentary canal in osteitis fibrosa disseminata - - - - - 710
— system, anomalies of, associated with diaphragmatic hernia - - - 637
Alkaline urine in ætiology of recumbency calculi - - - - - - 102
Altounyan Hospital, Aleppo, visit to 412
Amaurosis fugax (*see* 'Black Out')
Ammonia, œsophageal stricture due to swallowing of - - - 564, 565
Ampulla of Vater, cancer in - - 757
Anæsthesia due to intracavernous carotid aneurysms - 267, 272 et seq.
— for operations for bronchial carcinoma 184
Anastomotic ulcer, gastroscopic appearance in - - - - - - 41
Aneurysm(s), iliac (*see* Iliac Aneurysm)
— intracavernous carotid (*see* Carotid Aneurysms)
— intracranial, classification of - - 268
— supraclinoid, differential diagnosis from intracavernous carotid aneurysm - - - - 291, 297
Angiography in intracavernous carotid aneurysms - - - - - 295
Angioma of lung - - - - - 177
Ankylosis in protrusio acetabuli - - 692
Anosmia in olfactory groove meningiomas 128, 140, 163
Antimony sodium tartrate in elephantiasis - - - - - - - 89
Aojaoja (thread) used by trephiners of Blanche Bay - - - - - 2
Appendix, carcinoid tumours of (*see* Carcinoid Tumours)
— intussusception into cæcum, case report - - - - - - 444

PAGE

Argentaffin tumours - - - - - 306
Arteries, bronchial, anatomical - - 171
— carotid, aneurysms of (*see* Carotid Aneurysms)
— pulmonary, anatomical - - - 169
Arthritic changes due to degeneration of caput femoris after fractures of femur neck - - - 730, 738
— — in protrusio acetabuli 691, 692, 700
Aspiration biopsy - - - - - 324
— — comment - - - - - - 327
— — results - - - - - - 324
— — technique - - - - - 324
Atrophic gastritis, gastroscopic appearance in - - - - - - 39
AUSTIN, W. E.: Simultaneous perforation of multiple peptic ulcers - 387
Aviation, 'black out' in (*see* 'Black Out')
Axilla, progressive streptococcal ulceration in, case of - - - 254
Axillary lymphatics in metastases from breast - - - - - - 480
Azygos vein, lobe of - - - - 168

BALL, Sir GIRLING: Leiomyoma of the stomach - - - - - 942
BANKART, A. S. BLUNDELL: An operation for recurrent dislocation (subluxation) of the sternoclavicular joint - - - - - - 320
— — The pathology and treatment of recurrent dislocation of the shoulder-joint - - - - 23
Barium meal examination in diagnosis of pancreatitis - - - - 398
BARRETT, N. R., and ELKINGTON, J. St. C.: Two cases of endothelioma of the pleura - - - - - - 314
Basophil adenomata of pituitary - 813, 814
Belts, body, to combat 'black out' in aviation - - - - - - 756
Bile, white, in pancreatic disease, significance of - - - - 408
Bile-duct, common, carcinoma of lower end of - - - - - - 757
— — — — — aetiology - - - 762
— — — — — macroscopical appearances - - - 759
— — — — — microscopical appearances - - - 760
— — — — — summary - - - 763
— — traumatic severance of, case report - - - - - - 646
Biliary carcinoma, incidence of - - 757
— — sites of - - - - - - 758
Bilirubin readings to determine degree of pancreatic obstruction - - 399
Biopsy, aspiration - - - - - 324
— — comment - - - - - - 327
— — results - - - - - - 324
— — technique - - - - - 324
'Black out' in aviation - - - - 749
— — — causation - - - - 753
— — — clinical features - - - 752

PAGE

'Black out' in aviation, methods used to combat - - - - - 755
Bladder, cancer of, periodicity in - - 115
— mucosa, stone formation in relation to condition of - - - 259
— papilloma a of, periodicity in - 118
— stenosis of neck of, operative treatment - - - - - - - - 764
— — — — — commentary - - 766
— — — — — conclusions - - 767
— — — — — technique - - - 764
Blanche Bay, New Britain, trephiners of: their instruments and methods 1
BLAUVELT, HUGH: Pleuro-œsophageal fistula in empyema - - - 46
Blindness, bilateral, in pituitary adenoma 829, 858
— in one eye in pituitary adenomata - 828
— — — — — case reports - - 846
— temporary, in aviation (*see* 'Black Out')
Blood-calcium increase in aetiology of recumbency calculi - - 100, 104
Blood-clot formation after transfrontal operations on pituitary 243, 823, 893
Blood-coagulation tests in pancreatic disease - - - - - - 401
Blood-supply of vertebral bodies - 79
Blood-urea test in pancreatic disease - 400
Blood-vessels, ligation of, during pulmonary resection, effects of - 175
Blood-volume in intestinal obstruction and strangulation - - - 418
— — — — conclusions - - - 427
— — — — discussion - - - 425
— — — — experimental results - 421
— — — — method of measurement 419
Body belts to combat 'black out' in aviation - - - - - - 756
Bone changes in osteitis fibrosa disseminata - - - - - - 710
— decalcification of, in aetiology of recumbency calculi - - - 100
— infection in aetiology of recumbency calculi - - - - - - 106
— spontaneous absorption of, case report - - - - - - 944
Bone-graft, tibial, massive necrosis of muscles of leg following removal of 780
Bone-pegging plus nail for intracapsular fractures of neck of femur 729, 744, 746
Bougie treatment of non-malignant stenosis of œsophagus 561 et seq.
— — — — — dangers - - - 581
— — — — — relapses after - - 581
BOWESMAN, CHARLES: Intra-arterial glycerin treatment of elephantiasis 86
Brain (*see also* Cerebral)
— in osteitis fibrosa disseminata - 710
Breast, cancer of, biopsy material from 326
— — concerned with pregnancy - 775
— — incidence of different types of growth - - - - - - 777
— — intracystic - - - - - 775
— — lymphatics in tissue of 478 et seq.

PAGE

Breast, cancer of, pathological grading of 773
— — periodicity in - - - - 114
— — survival rates of different types of growth - - - - 777
— — with colloid degeneration - - 775
— chronic mastitis - - - - 770
— duct carcinoma of - - 774, 777
— — papilloma of - - - - 772
— fibro-adenoma of - - - - 771
— multiple cysts of - - - - 771
— Paget's disease of nipple - - 777
— physiological changes in - - 768
— primary actinomycosis of, case reports - - - - 30, 32
— — — commentary - - - 33
— — — summary - - - - 34
— simple and malignant pathological conditions of - - - - 768
— solitary cyst of - - - - 770
BRODSKY, ISADORE: The trephiners of Blanche Bay, New Britain: their instruments and methods - - 1
BROMLEY, J. F., LEEDHAM-GREEN, J. C., and RABAN, JOHN: Plasmocytoma of the innominate bone - - 90
Bronchial adenoma - - - - 177
— arteries, anatomical - - - 171
Bronchoscopy in bronchial adenoma - 177
— — carcinoma - - - - 181
Bronchospirometry to examine pulmonary ventilation - - - - 167
Bronchus, anatomy of - - - 168
— carcinoma of - - - - 178
— — after-treatment - - - - 191
— — anæsthesia - - - - 184
— — diagnosis - - - - - 180
— — pathology - - - - 179
— — pneumonectomy - - - 186
— — pre-operative preparation - - 185
— — the question of operability - 183
— — treatment - - - - - 183
— — — preliminary pneumothorax - 185
— — type of operation - - - 183
— closure of, following lobectomy - 175
BROSTER, L. R.: The surgery of the adrenal cortex - - - - 925
Bursa of coracoclavicular ligament, calcification of - - - - 329
— epicondylar, at elbow, calcification in, case report - - - - 446

CÆCUM, intussusception of normal appendix into, case report - 444
— primary solitary diverticulitis of, case report - - - - 200
— simple non-specific ulcer of - - 526
— — — — aetiology and pathology - 528
— — — — case report - - - 526
— — — — clinical features - - 529
— — — — conclusion - - - 530
— — — — discussion - - - 528
— — — — treatment - - - 530
Calcification of bursa of coracoclavicular ligament - - - - - 329

PAGE

Calcification in epicondylar bursa at elbow, case report - - - 446
Calcium diet, high, in aetiology of recumbency calculi - - - 103
— salts from bones into blood-stream in aetiology of recumbency calculi 100
— — in urine, increase due to dehydration, calculous formation and 101
Calculi, biliary, in aetiology of carcinoma 762
— urinary (*see* Urinary Calculi)
CAMERON, J. R.: Simple non-specific ulcer of the cæcum - - 526
Cancer in ampulla of Vater - - 757
— of bile-duct (*see* Bile-duct)
— breast (*see* Breast)
— bronchus (*see* Bronchus)
— jejunum (*see* Jejunum)
— kidney, biopsy material from - - 326
— œsophagus, intrathoracic reconstruction of lower œsophagus - - 10
— oral, periodicity in - - - 114
— of pancreas (*see* Pancreas)
— periodicity in (*see* Periodicity in Cancer)
— of rectum, lymphatics in relation to 490
— relation of lymphatic vessels to spread of (*see* Lymphatic Vessels)
— of stomach, gastroscopic appearances of - - - 43–45
— — and rectum in same patient, case report - - - - - 201
— thyroid, periodicity in - - - 115
— vesical, periodicity in - - - 115
Capsular changes in acetabular protrusions - - - - - 703
Caput femoris, degeneration of, in fractures of femur neck 730, 738, 740
Carcinoid tumours of appendix, history 303
— — — author's cases - - - 307
— — — clinical features - - - 306
— — — origin - - - - - 305
— — — pathology - - - - 304
— — — prognosis - - - - 307
— — — summary - - - - 312
— — — treatment - - - - 307
Carcinoma (*see* Cancer)
Cardiac lobe of lung, anatomical - - 169
Cardioplasty for œsophageal stenosis - 572
Cardiospasm, gastroscopic appearance in - - - - - - - 41
— nerve-supply of gastro-œsophageal junction in surgery of - - 342
Cardiovascular changes associated with acromegaly - - - - - 914
Carotid aneurysms, intracavernous - 267
— — — bilateral - - - - 287
— — — clinical evolution - - 289
— — — — types - - - - 269
— — — conclusion - - - - 300
— — — differential diagnosis - - 291
— — — material - - - - 267
— — — pathology - - - - 292
— — — personally observed cases - 272
— — — previously recorded cases - 268
— — — radiological appearances - 294

PAGE

Carotid aneurysms, intracavernous, syndrome of anterior end of sinus 271, 281
— — — — middle of sinus - 271, 279
— — — — posterior end of sinus 271, 272
— — — treatment - - - - 297
Cataract formation due to X-ray treatment in chromophobe adenoma of pituitary - - - - 874
Catarrhal gastritis, acute, gastroscopic appearance of - - - - 38
CATHIE, I. A. B.: aspiration biopsy - 324
Cavernous sinus, saccular aneurysms of internal carotid artery in (*see* Carotid Aneurysms)
Cerebral œdema after transfrontal approach for pituitary adenoma - 823
Cerebrospinal rhinorrhœa in transsphenoidal decompression of pituitary adenoma - - - 246
Cervical abscess in acute infective osteomyelitis of spine - - - 79
CHARTERIS, ALEXANDER A., RENTON, J. MILL, and HEGGIE, JAMES FERGUSON: Riedel's thyroiditis and its treatment by radium - 54
Child(ren), benign testicle in, case report - - - - - - 443
— hernia through foramen of Winslow in, case report - - - - 648
— sarcoma of intestine in (*see* Sarcoma)
CHITTY, E. C.: A case of œsophageal polypus accompanied by a tumour of an accessory thyroid gland - 193
Cholæmia as cause of death in operations for pancreatic disease - - 406
Cholecyst-duodenostomy in obstructive jaundice - - - - - - 403
Cholecyst-enterostomy in obstructive jaundice - - - - - - 403
Cholecyst-gastrostomy in obstructive jaundice - - - - - - 403
Cholesteatoma of Müller - - - 506
Chondromas of lung - - - - 176
Chromophobe adenomata of pituitary (*see* Pituitary Adenomata)
Clairmont and Ehrlich operation for recurrent dislocation of shoulder-joint - - - - - - 23
Clamp-incision (Irwin's) for dealing with stenosis of the bladder neck - 765
Classification of cancer of lung - - 179
Coccygeal abscess in acute infective osteo-myelitis of spine - - 80
Cœliac plexus in nerve-supply to upper end of stomach - 338 et seq.
COLEMAN, MARK: Osteitis fibrosa disseminata, report of a case - - 705
Congenital dislocation of hip - - 791
— — — case reports - - - 792
— fibrous stricture of œsophagus - 562
— origin of protrusio acetabuli, theory of - - - - - - 694
— ranula of left submaxillary gland, case report - - - - 947

PAGE

Constipation in aetiology of recumbency calculi - - - - - - 106
Coracoclavicular ligament, calcification of bursa of - - - - 329
Corrosives, œsophageal stricture due to swallowing of - - 564 et seq.
Coto (scraper) used by trephiners of Blanche Bay - - - - - 2
Cotyloid ring cartilage and femoral head in hip-joint mechanism - - 702
Coxa vara, association with protrusio acetabuli - - - - - - 695
Cranial hyperostoses in relation with meningiomas (*see* Meningiomas)
— nerve palsies in intracavernous carotid aneurysm, recovery in - - 290

Critical Reviews :—

The surgery of the adrenal cortex 925
The surgical treatment of obstructive jaundice in pancreatic disease - - - - - - 393
Tumours of the lung - - - 166
Cushing, Dr. Harvey - - - 809
Cutaneous (*see* Skin)
Cyclopropane anæsthesia for pneumonectomy - - - - - - 184
Cysts in chromophobe adenomata of pituitary - - - - - - 889
— intrapelvic, probably of mesonephric origin (*see* Mesonephric Cysts)
— multiple, of breast - - - 771
— solitary, of breast - - - 770

DECALCIFICATION of bones in aetiology of recumbency calculi 100
Decompression in olfactory groove meningiomas - - - 132, 134
— of pituitary adenoma (*see* Pituitary Adenomata)
Dehydration, increased calcium in urine due to, calculus formation and - 101
Dermis, lymphatic plexus of deeper portion - - - - - - 469
— — — superficial part - - - 466
Diaphragmatic hernia through œsophageal hiatus, with volvulus of stomach - - - - - - 632
— lesions associated with volvulus of stomach - - - - - - 640
Diencephalic trauma in transfrontal decompression of pituitary adenoma - - - - - - 224
DICK, JOHN C.: Carcinoma of the lower end of the common bile-duct - 757
Diet in treatment of recumbency calculi 108
— vitamin-A deficient, stone formation and - - - - - - - 259
Dietetic factors in aetiology of recumbency calculus - - - 102
Dilator, vaginal, evolution and development of - - - - - - 232
Dislocation of hip, congenital - - 791
— — — case reports - - - 792

PAGE

Dislocation, recurrent, of sternoclavicular joint, operation for - - 320
— of shoulder-joint (*see* Shoulder-joint)
Diverticulitis of cæcum, primary solitary, case report - - - - - 200
Diverticulum, Meckel's, in obturator hernial sac - - - - - 515
— of œsophagus, perforation of - - 52
— stomach, gastroscopic appearance in 41
Dorsal abscess in acute infective osteomyelitis of spine - - - 80
Drills, canalized, for Kirschner's guide wires - - - - - - 744
Drusen in mammary actinomycosis 31, 32
Duct carcinoma of breast - - 774, 777
— papilloma of breast - - - 772
— — — malignant - - - - 775
Duodenal obstruction, blood-volume changes in - - - - - 421
Dye method of measuring blood-volume 420
Dysphagia in Riedel's thyroiditis - 56

EDWARDS, A. TUDOR: Tumours of the lung - - - - - 166
Ehrlich and Clairmont operation for recurrent dislocation of shoulder-joint - - - - - - 23
Elbow-joint: Calcification in epicondylar bursa at, case report - - 446
— displacement of detached medial epicondyle of humerus into (*see* Humerus)
Elephantiasis, intra-arterial glycerin treatment of - - - - 86
— — — — discussion - - - 89
— — — — summary - - - 89
ELKINGTON, J. ST. C., and BARRETT, N. R.: Two cases of endothelioma of the pleura - - - 314
Empyema, pleuro-œsophageal fistula in (*see* Pleuro-œsophageal Fistula)
Endocrine glands in osteitis fibrosa disseminata - - - - - 709
Endothelioma of lung - - - - - 176
— pleura - - - - - - - 314
— — comment - - - - - 317
— — two case reports - - - 314
Enterocele in obturator hernia - - 522
Epicondylar bursa at elbow, calcification in, case report - - - - 446
Epicondyle, medial, of humerus, detachment of (*see* Humerus)
Epidermoids in diploe of bones of skull 506
— — — — case reports - - - 507
— — — — pathology - - - 512
— — — — summary - - - 514
Epididymis, chronic non-tuberculous disease of - - - - - 800
— — — — aetiology - - - 804
— — — — case reports - - - 800
— — — — conclusions - - - 808
— — — — discussion - - - 806
Epidural spinal suppuration (*see* Spinal Epidural Suppuration)

PAGE

Epilepsy due to olfactory groove meningiomas - - - - - - 141
— following transsphenoidal approach to pituitary adenoma - - 878
Epimeningitis spinalis (*see* Spinal Epidural Suppuration)
Epiphysial ossification, accelerated, protrusio acetabuli and - - 693
Epiphysiolysis as precursor of acetabular deformity - - - - - 697
Epithelioma of foot, lymphatics in relation to - - - - - - 489
— leg, lymphatics in relation to 484 et seq.
Ewing's sarcoma, periodicity in - - 116
Excretory system, development of - 500
Exophthalmos due to meningiomas - 603
Exotheliomas - - - - - - 125

Experimental Surgery:
The behaviour of the blood-volume in intestinal obstruction and strangulation - - - - - 418
Extensor carpi radialis brevis - - 95
Extradural clot formation in transfrontal approach to pituitary adenomata 893
Eyeball, displacement of, in meningiomas 603

FACE, anæsthesia of, due to intracavernous carotid aneurysms 267, 272, et seq.
Fæces, examination of, in diagnosis of type of pancreatic disease - - 400
Fascial sling operation for recurrent dislocation of shoulder-joint - 376
Fat in fæces in diagnosis of type of pancreatic disease - - - 400
Femoral epiphysis, slipped, association with protrusio acetabuli - - 695
Femur, intracapsular fracture of neck of, closed operation for, bone-peg plus nail - - - - - - 729
— — — — — — failure of nail to hold in caput femoris - - 727
— — — — — — function after - 728
— — — — — — method of anæsthesia - - 724
— — — — — — obliquity of fracture lines - - 722
— — — — — — osteo-arthritis due to changes in caput femoris - 730
— — — — — — reduction - - 725
— — — — — — results in recent fractures - - 721
— — — — — — — ununited fractures - - 734
— — — — — — selection of patients 721
— — — — — — technique - - 741
— — — — — — in ununited cases, changes in caput femoris - - 738
— — — — — — — poor general condition 737

PAGE

Femur, intracapular fracture of neck of, closed operation for in ununited cases, pseudo-arthrosis - - 739
— — — — — — — weight-bearing - 727
— — — — — — — X-ray evidence of osseous union - 725
Fibro-adenoma of breast - - - 771
Fibroma of lung - - - - 177
Fibrosarcoma of abdominal wall, lymphatics in relation to - - - 493
Fibular bone-peg in fractures of femur neck - - - 729, 744, 746
Finger, an unusual accident to, case report - - - - - 198
Fistula, pleuro-œsophageal (*see* Pleuro-œsophageal Fistula)
— thyroglossal, complete - - - 714
— — — case reports - - - 716
— — — conclusions - - - 720
— — — discussion - - - - 718
Fluid-mechanism of hip-joint - - 702
Fluids in prevention of recumbency calculi - - - - - 107
Fœtus, female, developmental phases of 937
Foix, syndrome of - - - - 271
Foot, epithelioma of, lymphatics in relation to - - - - 489
Foramen of Winslow, hernia through, in baby, case report - - - 648
Foster Kennedy syndrome in olfactory groove meningiomas - 140, 163
FOWWEATHER, F. S., and PYRAH, LESLIE N.: Urinary calculi developing in recumbent patients - - 98
Fractures of femur (*see* Femur)
FRASER, SIR JOHN: The surgical treatment of obstructive jaundice in pancreatic disease - - - 393
Fuchsine stain (Ponceau) for virilism - 930
'Fugitive' acromegaly - - - 814
Fungus duræ matris - - - - 593
Fusiform aneurysms of internal carotid artery in cavernous sinus (*see* Carotid Aneurysms)

GAIT in protrusio acetabuli - - 691
Gall-bladder (*see also* Bile-duct)
— condition of, in diagnosis of pancreatic disease - - - - - 398
Gall-stones in aetiology of biliary carcinoma - - - - - 762
Gastrectomy stoma, gastroscopic appearance of - - - - - - 41
Gastric artery, left, results of resections of - - - - - - 343
— nerves in supply to gastro-œsophageal junction - - - 337, 338, 339
— ulcers (*see* Peptic Ulcer)
Gastritis, gastroscopic appearances in 38, 39
Gastro-enterostomy for jejunal ulcer, gastroscopic appearance after - 41
Gastro-œsophageal junction, nerve-supply of - - - - - - 333
— — — lower end of œsophagus - 333

PAGE

Gastro-œsophageal junction, nerve supply of, surgical significance - - 341
— — — upper end of stomach - 337
Gastroscopic appearances in health and disease, benign deformities - 41
— — — — — ulcers - - - 39
— — — — gastritis - - - 38
— — — — introduction - - - 35
— — — — neoplasms - - - 43
— — — — normal appearances - 36
— — — — post-operative conditions 42
Gastrostomy in œsophageal stenosis 562 et seq., 583
— pleuro-œsophageal fistula in empyema - - - - - - - 53
Genitalia in osteitis fibrosa disseminata - 709
GHARPURE, K. C.: Volvulus of stomach ending in perforation - - 630
GILL, W. G., and MANN, W. N.: Tuberculosis of the spleen with tuberculous subphrenic abscess - 661
GILMOUR, JOHN: Adolescent deformities of the acetabulum: an investigation into the nature of protrusio acetabuli - - - - - 670
— — The relationship of acetabular deformity to spontaneous osteo-arthritis of the hip-joint - 700
Glenoid ligament in recurrent dislocation of shoulder-joint - - - 25
Glycerin treatment of elephantiasis - 86
— — — discussion - - - - 89
— — — summary - - - - 89
Glycosuria, acromegalic - - - 913
Goitre, lymphadenoid, Riedel's thyroiditis and - - - - - 59
GORDON-TAYLOR, G.: On abdominal injuries and their recipients - 217
GRACE, A. J.: Primary solitary diverticulitis of the cæcum - - 200
Granuloma of thyroid - - - 69
Granulomatous ulcers resembling tuberculous ulcers of stomach - - 379
— — — — — — — case reports - 380
GRAY, J.: An investigation into the condition of the bladder mucosa in relation to stone formation - 259
GRAY, J. H.: The relation of lymphatic vessels to the spread of cancer - 462
GROVES, E. W. HEY: Recurrent dislocation of the shoulder—a plea for a simple operation - - - 375

HÆMOLYTIC streptococcal ulceration, progressive, case of - - 254
— — — — discussion - - - 257
— — — — summary - - - 257
Hæmorrhagic cysts in chromophobe adenomata of pituitary - - 889
HAMILTON, A. R.: A case of calcification in the epicondylar bursa at the elbow - - - - - 446
Hashimoto's disease, Riedel's thyroiditis and - - - - - - - 58

PAGE

Headache in acidophil pituitary adenomata - - - - - - 908
— olfactory groove meningiomas - 141
Head-saws, evolution and development of 457
Heart in osteitis fibrosa disseminata - 709
HEGGIE, JAMES FERGUSON, RENTON, J. MILL, and CHARTERIS, ALEXANDER A.: Riedel's thyroiditis and its treatment by radium 54
HEGGS, F. MITCHELL: Carcinoma of the jejunum, acute intestinal obstruction - - - - - - 532
Hemianopia, bitemporal, in pituitary adenomata - - - - - 827
— — — — case reports - - - 829
— homonymous, in pituitary adenomata 827
— — — — case reports - - - 837
Hemicraniosis - - - - - - 594
HENDERSON, W. R.: The anterior basal meningiomas - - - - - 124
— — The pituitary adenomata, a follow-up of the surgical results in 338 cases (Dr. Harvey Cushing's series) - - - - - - 811
Hepatic plexus in nerve-supply to upper end of stomach - - 338, 339
Hernia, diaphragmatic, through œsophageal hiatus, with volvulus of stomach - - - - - - 632
— obturator (*see* Obturator Hernia)
— through foramen of Winslow in baby, case report - - - - - 648
HEWETSON, J. T., and REDMAN, THIRZA: Observations on simple and malignant pathological conditions of the breast - - - - - 768
HILL, W. C. OSMAN, and PAUL, MILROY: Volvulus of stomach associated with a rare form of diaphragmatic hernia - - - - - 632
Hip, congenital dislocation of - - 791
— — — case reports - - - 792
— normal mechanism of - - - 701
— in protrusio acetabuli (*see* Protrusio Acetabuli)
Hirsuties in adrenogenital syndrome 927 et seq.
Hormone, male sex, biological tests for - 932
— — — isolation of - - - 933
— sex, biological aspects - - - 939
Hour-glass contraction of stomach, gastroscopic appearance in - 41
HUGHES, J. HOWELL: Gastroscopic appearances in health and disease 35
Humerus, detached medial epicondyle of, displaced into elbow - - 785
— — — — — — aetiology - - 785
— — — — — — case reports - - 789
— — — — — — diagnosis - - 786
— — — — — — prognosis - - 789
— — — — — — treatment - - 788
Hydrochloric acid, œsophageal stricture due to swallowing of - - 567
Hyoid bone in relation to thyroglossal tract - - - - - - 719

PAGE

Hyperostoses in relation with meningiomas (*see* Meningiomas)
Hypertelorism - - - - - - 588
— case reports - - - - - - 589
— discussion - - - - - - 591
Hypertrophic gastritis, chronic, gastroscopic appearances in - - - 38

ICEBERG tumours of skull - - 601
Icteric index as estimate of degree of pancreatic obstruction - - 399
— — in prognosis of pancreatic disease 406
Ileum, leiomyosarcoma of, case report 540
— — discussion - - - - - 542
— obstruction of, blood-volume changes in - - - - - - - 422
Iliac aneurysm, common, leaking, treatment by wiring - - - 624
— — — — — — — anatomy of part - 624
— — — — — — — case report - - 625
— — — — — — — summary - - 627
Incision for exposing anterior aspect of shoulder-joint - - - - - 26
— pneumonectomy - - - 186, 187
Inflammatory causes of non-tuberculous disease of epididymis - - 804
Infraspinatus muscle, sarcoma of, case report - - - - - - 439
Inguinal route for cure of obturator hernia - - - - - - 524
Innominate bone, plasmocytoma of - 90
— — case reports - - - - 90
— — — discussion - - - - 93
Instruments, surgical, evolution and development of, head-saws - - 457
— — — — vaginal dilator and speculum - - - - - 232
Intersexuality - - - - - - 934
— theory of - - - - - - 936
Intestinal obstruction in baby due to hernia through foramen of Winslow, case report - - 648
— — due to carcinoma of jejunum - 532
— — and strangulation, blood-volume in (*see* Blood-volume)
Intestine, sarcoma of (*see* Sarcoma)
Intracapsular fractures of femur neck (*see* Femur)
Intracavernous carotid aneurysms (*see* Carotid Aneurysms)
Intracerebral cysts in pituitary adenomata - - - - - - - 891
Intracranial aneurysms, classification of 268
— extensions in chromophobe pituitary adenoma - - - - - - 900
Intra-ocular pressure in causation of 'black-out' in aviation - - 753
Intrapelvic cysts, probably of mesonephric origin (*see* Mesonephric Cysts)
Intrasellar cysts in pituitary adenomata 889
Intrathoracic reconstruction of lower œsophagus, case report - - 10
— — — — commentary - - - 17

PAGE

Intrathoracic reconstruction of lower œsophagus, summary - - 22
Intussusception of normal appendix into cæcum, case report - - - 444
IRWIN, W. H.: The operative treatment of stenosis of the vesical neck - - - - - - - 764

JACKMAN, W. A.: A case of spontaneous absorption of bone - - 944
Jaundice, obstructive, in pancreatic disease (*see* Pancreatic Disease)
JEFFERSON, GEOFFREY: On the saccular aneurysms of the internal carotid artery in the cavernous sinus - 267
Jejunal obstruction, blood-volume changes in - - - - - 421
— ulcer, gastro-enterostomy for, gastroscopic appearance after - - 41
Jejunum, carcinoma of - - - 532
— — case reports - - - - 534
— — clinical aspect - - - - 532
— — diagnosis - - - - - 533
— — discussion - - - - 538
— — physical signs - - - - 533
— lymphosarcoma of, with perforation, case report - - - - 543
— — — — discussion - - - 546
JEMSON, J., and SLESINGER, E. G.: Carcinoma of the stomach and the rectum in the same patient - 201

KAUR (blowpipe) used by trephiners of Blanche Bay - - - 2
Kennedy (Foster) syndrome in olfactory groove meningiomas - 140, 163
Kia (forceps and scoop) used by trephiners of Blanche Bay - - 2
Kidney(s), carcinoma of, biopsy material from - - - - - - 326
— in case of tuberculosis of spleen - 666
— osteitis fibrosa disseminata - - 709
KING, THOMAS: The closed operation for intracapsular fracture of the neck of the femur, final results - 721
KINI, M. G.: A case of congenital ranula of the left submaxillary gland - - - - - - 947
KINI, M. G., and RAO, M. N.: Granulomatous ulcers resembling tuberculous ulcers of the stomach - 379
KINSELLA, VICTOR J.: Complete thyroglossal fistulæ - - - - - 714
Köhler's acetabular lines - - - 686
Koto (scraper) used by trephiners of Blanche Bay - - - - - 2
Kuara (thread) used by trephiners of Blanche Bay - - - - - 2
Kubika for cleansing head wounds in Blanche Bay - - - - - 7
Kultschitzky cells as origin of carcinoids 306
Kumu (taro leaf) for dressing trephine wounds in Blanche Bay - - 7

PAGE

LACTATING fibro-adenoma of breast 772
Lactation, prolonged, mammary actinomycosis and - - - - 33
Laminectomy in acute infective osteomyelitis of spine - - - 84
LANGSTON, H. H.: An unusual case of progressive streptococcal ulceration - - - - - - - 254
Laryngeal compression in Riedel's thyroiditis - - - - - 59
Lateral osteoplastic approach to pituitary adenoma - - - - - - 820
Leather-bottle stomach, gastroscopic appearance of - - - - - 44
LEEDHAM-GREEN, J. C., BROMLEY, J. F., and RABAN, JOHN: Plasmocytoma of the innominate bone - - 90
Leg, epithelioma of, lymphatics in relation to - - 484 et seq.
— massive necrosis of muscles of, after removal of bone-graft from tibia 780
Leiomyoma of stomach, case report - 942
Leiomyosarcoma of ileum, case report - 540
— — discussion - - - - - 542
Leukæmia, periodicity in - - - 116
LEWIS, D. LINCOLN: Two cases of sarcoma of the small intestine with unusual features - - 540
Ligation of blood-vessels during pulmonary resection, effects of - 175
— carotid artery - - - - - 297
— thyroglossal tract for fistulæ 716, 718, 719
Ligneous thyroiditis - - - - - 69
Lipoma of lung - - - - - - 177
Liver in case of tuberculosis of spleen - 664
'Liver death' after operations for pancreatic disease - - - 407
LIVINGSTON, P. C.: The problem of 'black out' in aviation - - 749
Lobectomy (*see under* Lung, Tumours of)
Lobes of lungs, anatomical variations - 168
Long-long as complication of trephination in Blanche Bay natives - - 7
Lordosis in protrusio acetabuli - - 691
Lorenz osteotomy in ununited intracapsular fractures of femur neck 737, 739
Lumbar abscess in acute infective osteomyelitis of spine - - - 80
Lung(s), anatomy of - - - - 168
— angioma of - - - - - - 177
— cancer of (*see* Bronchus, Carcinoma of)-
— chondromas of - - - - - 176
— endothelioma of - - - - - 176
— fibroma of - - - - - - 177
— lipoma of - - - - - - 177
— lobes of, variations in anatomy of - 168
— lymphatic drainage from - - 171
— tumours of - - - - - - 166
— — anatomical - - - - - 168
— — bronchial adenoma - - - 177
— — closure of bronchus - - - 175
— — compensatory mechanisms after pulmonary resection - - 171

PAGE

Lung tumours, diagnosis of intrapulmonary tumours - - - 176
— — effects of vascular ligation at operation - - - - 175
— — pleural and pulmonary reflex effects at operation - - 174
— — rare varieties - - - - 176
Lymph, fixed direction of flow - - 475
— rate of flow - - - - - 473
Lymphadenoid goitre, Riedel's thyroiditis and - - - - - 59
Lymphadenoma, periodicity in - - 117
Lymphatic leukæmia, periodicity in - 117
— vessels, criteria for identification of - - - - - - 463
— — permeability and strength of - 473
— — pulmonary, anatomical - - 171
— — regenerative capacity of - - 477
— — relation to spread of cancer, deductions from pathological findings - - - - - 493
— — — — — findings in pathological material used - 477
— — — — — functional basis - - 473
— — — — — general summary - 494
— — — — — introduction - - 462
— — — — — literature - - - 494
— — — — — method of investigation 462
— — — — — structural basis - - 463
— — of skin - - - - - - 466
Lymphoblastoma, periodicity in - - 117
Lymphosarcoma, periodicity in - - 116
— of small intestine with perforation, case report - - - - 543
— — — — — discussion - - 546
LYSAGHT, A. C.: A case of traumatic severance of the common bile-duct - - - - - - 646

McCURRICH, H. J.: Calcification of the bursa of the coracoclavicular ligament - - - - - - 329
MCFARLAND, BRYAN: Congenital dislocation of the hip - - - 791
MCGAVIN, DONALD: Chronic non-tuberculous disease of the epididymis - - - - - - 800
Mal for dressing trephine wounds in Blanche Bay - - - - 7
Malan dressing for trephine wounds in Blanche Bay - - - - 7
Male sex hormone, biological tests for - 932
— — — isolation of - - - - 933
MANN, W. N., and GILL, W. G.: Tuberculosis of the spleen with tuberculous subphrenic abscess - - 661
Mastitis, chronic - - - - - 770
Meckel's diverticulum in obturator sac - - - - - - - 515
Mediastinal lymph-glands, inflammation of, causing perforation of œsophagus and empyema wall - 51
Meme na bnai dressing for trephine wounds in Blanche Bay - - 2

PAGE

In Memoriam :—
Graham Scales Simpson - - 922
Sir David Wilkie - - - 390
Meningiomas, anterior basal, discussion 162
— — — introduction - - - 124
— — — meningiomas in general - 125
— — — olfactory groove meningiomas 127
— — — pre-olfactory meningiomas - 142
— — — sphenoid ridge meningiomas 146
— — — summary - - - - 163
— — — tuberculum sellæ meningiomas 143
— hyperostoses in relation with - - 593
— — — — circulation of meningiomas 598
— — — — clinical types of - - 600
— — — — historical survey - - 593
— — — — material - - - 595
— — — — the parts played by the skull and the meningioma 614
— — — — pathological features of hyperostosis - - 603
— — — — — — meningiomas - 598
— — — — routes of invasion - - 618
— of olfactory groove - - - 127
— — — case reports - - - 129
— — — clinical manifestations - - 137
— pre-olfactory - - - - - 142
Meningitis following transsphenoidal operations for pituitary adenomata - - - - - - 823
Menopause, physiological changes in breast during - - - - 769
Menstrual dysfunction in adrenogenital syndrome - - - 927 et seq.
Menstruation, physiological changes in breast during - - - - 768
Mental changes in olfactory groove meningiomas - - - - 141
— symptoms following transfrontal approach to pituitary adenoma 877
Mesentero-axialis type of volvulus of stomach - - - - - - 639
Mesonephric cysts, case report - - 496
— — aetiology of - - - - 500
— — diagnosis, treatment, and prognosis 504
— — review of literature - - - 501
— — summary - - - - - 504
Mesonephros in development of excretory system - - - - 500
Metacarpal bones, spontaneous absorption of, case report - - - 944
Metanephros in development of excretory system - - - - 500
Mikulicz's disease, periodicity in - - 117
MITCHELL, G. A. G.: The nerve-supply of the gastro-œsophageal junction - - - - - - 333
MITCHELL, G. F.: Acute intestinal obstruction in a baby 15 months old due to hernia through the foramen of Winslow - - 648
Monocular defects in pituitary adenomata 829
— — — — case report - - - 856
MOORE, THOMAS: Carcinoid tumours of the appendix - - - 303
— — An unusual finger accident - 198

PAGE

Morphia as aid to diagnosis of pancreatic disease - - - - - - 398
MOWAT, G. T.: A case of intussusception of the normal appendix into the cæcum - - - - - 444
'Mud-stones', formation of - - 99
Muscles of leg, massive necrosis of, following removal of tibial bone-graft - - - - - - 780
Mycosis fungoides, periodicity in - 117
Myeloid leukæmia, periodicity in - 116

NAILING for fractures of femur neck (*see* Femur, Intracapsular Fractures of)
Nasopharyngeal extensions in chromophobe pituitary adenomata - 897
Neck of femur, intracapsular fractures of (*see* Femur)
Nerve to extensor carpi radialis brevis - 95
— paralysis, cranial, in intracavernous carotid aneurysm, recovery in - 290
Nerve-supply of gastro-œsophageal junction - - - - - - - 333
— — — lower end of œsophagus - 333
— — — surgical significance - - 341
— — — upper end of stomach - - 337
Nervous signs in endothelioma of pleura 315, 317, 318
Nipple, Paget's disease of - - - 777
Nitric acid, œsophageal stenosis due to - - - - - - - - 580

OAKLEY, A. R. H.: Intrapelvic cysts, probably of mesonephric origin - - - - - - - 496
Oat-celled carcinoma of lung - - 179
Obliterative appendicitis, carcinoid tumours and - - - - - 303
Obstructive causes of non-tuberculous disease of epididymis - - 805
— jaundice in pancreatic disease (*see* Pancreatic Disease)
Obturator hernia - - - - - 515
— — aetiology of - - - - - 521
— — anatomy of region - - - 520
— — case reports - - - - - 515
— — museum specimens - - - 518
— — symptomatology - - - 522
— — treatment - - - - - 523
— route for cure of obturator hernia 524
Œdema, cerebral, after transfrontal approach for pituitary adenoma 823
Œsophageal hiatus, diaphragmatic hernia through, with volvulus of stomach 632
— polypus accompanied by tumour of accessory thyroid gland - - 193
— tube feeding in pleuro-œsophageal fistula in empyema - - - 52
Œsophago-gastrostomy by fundus invagination - - - - - 19
— — trap-door (Herman Fischer's method) - - - - - 20

PAGE

Œsophago-gastrostomy, transthoracic, for stenosis - - - - - 573
Œsophagus, anatomical relations of - 50
— diverticulum of, perforation of - 52
— intrathoracic reconstruction of, case report - - - - - - 8
— — — commentary - - - 17
— — — summary - - - - 22
— lower end of, nerve-supply of - - 333
— non-malignant stenosis of - - 555
— — — causes of - - - - 574
— — — diagnosis - - - - 576
— — — illustrative cases - - - 559
— — — management of - - - 577
— — — symptomatology - - - 576
— peptic ulcer of, perforation of - 52
OGILVIE, W. H.: Intrathoracic reconstruction of lower œsophagus: note on unsuccessful case - - 10
Oleo seat to combat 'black-out' in aviation - - - - - - 756
Olfactory disturbances, various tumours causing - - - - - - 143
— groove meningiomas - - - 127
— — — case reports - - - 129
— — — clinical manifestations - - 137
— meningiomas, pre-olfactory - - 142
Ophthalmic artery in 'black out' in aviation - - - - - - 753
Optic atrophy due to anterior basal meningiomas - - - 129 et seq.
— radiation, pituitary adenoma involving, homonymous hemianopia due to - - - - - - 839
Oral cancer, periodicity in - - - 114
Organo-axialis type of volvulus of stomach - - - - - - 640
Osteitis fibrosa disseminata - - - 711
— — — case report - - - - 705
— — — introduction - - - 705
Osteo-arthritis due to degeneration of caput femoris after fractures of femur neck - - - 730, 738
Osteochondritis in aetiology of protrusio acetabuli - - - - - - 694
Osteoclastic hyperostoses with meningiomas - - - - - - - 609
Osteomyelitis of spine, (*see also* Spinal Epidural Suppuration)
— — acute infective - - - - - 71
— — — — aetiology - - - 78
— — — — bacteriology - - - 79
— — — — case reports - - - 72
— — — — complications - - 79
— — — — diagnosis - - - 81
— — — — mortality and prognosis - 83
— — — — pathology - - - 78
— — — — treatment - - - 83
Osteosynthesis, extra-articular, in fractures of the femur neck (*see* Femur, Intracapsular Fractures of)
Osteotomy in intracapsular fractures of femur neck - - 737, 739, 740
Otto pelvis in protrusio acetabuli - 691

PAGE

PABA leaves for dressing trephine wounds in Blanche Bay - - 7
Pachymeningitis spinalis externa (*see* Spinal Epidural Suppuration)
Paget's disease of nipple - - - 777
Pain after nailing for fractures of femur neck, significance of - - 734
— in obstructive jaundice due to pancreatic disease - - - - 397
— protrusio acetabuli, osteo-arthritic changes and - - - - 690
Palapalao for dressing trephine wounds in Blanche Bay - - - 2
Pampiniform plexus, spontaneous thrombosis of - - - - - 806
Pancreas, cancer of, age incidence of - 394
— — jaundice in - - - - 396
— — late results of operation in - 408
— — operative mortality - - - 404
— in osteitis fibrosa disseminata - 709
Pancreatic disease, incidence and type of jaundice in - - - - 396
— — surgical treatment of obstructive jaundice - - - - 393
— — — — — — causes of death - 406
— — — — — — conclusions - - 410
— — — — — — factors which influence mortality - 406
— — — — — — for and against operation - - 401
— — — — — — introduction - - 393
— — — — — — late results - - 408
— — — — — — mortality in types of cases - - 404
— — — — — — — various operations - - 404
— — — — — — pre-operative care 402
— — — — — — — diagnosis, barium meal examination - - 398
— — — — — — — — evidence for 396
— — — — — — — — special tests 399
— — — — — — sex and age analysis 394
— — — — — — types and period of occurrence - 394
— — — — — — — of operation - 402
— — — — — — — pancreatic disease 395
Papilliferous carcinoma of stomach, gastroscopic appearance of - 45
Papillœdema in olfactory groove meningiomas 129, 140, 156, 160, 163
Papilloma, duct, of breast - - - 772
— — — malignant - - - - 775
— periodicity in - - - - 118
Para-aortic nerve in supply to lower end of œsophagus - - - - 336
Paralysis, cranial nerve, in intracavernous carotid aneurysm, recovery in - 290
Parasympathetic nerve-supply to lower end of œsophagus - - - 336
— — upper end of stomach - - 341
PAUL, MILROY, and HILL, W. C. OSMAN: Volvulus of stomach associated with a rare form of diaphragmatic hernia - - - - - 632

PAGE

Pauwel's classification of fractures of femur neck - - - - - 723
— wedge osteotomy in ununited fractures of femur neck - - 740
Pelvic tilt in protrusio acetabuli - - 690
Pelvimetry in protrusio acetabuli - 684
Peptic ulcer, gastroscopic appearances in - - - - - - 39, 40
— — of œsophagus, perforation of - 52
— — simultaneous perforation of, case report - - - - - 387
— — — — literature - - - 387
— — — — summary - - - 388
Percaine spinal anæsthesia for pneumonectomy - - - - - - 184
Perforation due to volvulus of stomach, case report - - - - 630
— in lymphosarcoma of jejunum - 543
— simultaneously of multiple peptic ulcers, case report - - - 387
— — — — — literature - - - 387
— — — — — summary - - - 388
Perimeningitis spinalis (*see* Spinal Epidural Suppuration)
Periodicity in cancer and other neoplastic diseases - - - 113
— — — — — appendix - - - 121
— — — — — benign neoplasms - 118
— — — — — carcinoma - - - 114
— — — — — conclusions - - 118
— — — — — intermediate cancer group - - - 114
— — — — — leukæmia - - - 116
— — — — — lymphadenoma - - 117
— — — — — lymphoblastoma - 117
— — — — — sarcoma - - - 116
— — — — — summary - - - 120
Peripachymeningitis spinalis (*see* Spinal Epidural Suppuration)
Peroxide of zinc in streptococcal ulceration - - - - - - 256
PHILLIPS, G.: Transsphenoidal decompression of pituitary adenoma - 242
Phrenic plexus, inferior, in nerve-supply to gastro-œsophageal junction 337, 338
PICKERILL, H. P.: Hypertelorism, notes on three cases - - - - 588
Pigmentation in osteitis fibrosa disseminata - - - - - 711
Pituitary adenomata, follow-up of surgical results - - - 811
— — — — — acidophil - - - 902
— — — — — — early results - - 903
— — — — — — late results - - 911
— — — — — — post-operative mortality - - 902
— — — — — adenocarcinoma - 915
— — — — — — clinical varieties - 916
— — — — — conclusion - - 917
— — — — — contents - - - 811
— — — — — chromophobe - - 821
— — — — — — cysts - - - 889
— — — — — — early results - 824
— — — — — — intracranial extensions - - 900

PAGE

Pituitary adenomata, follow-up of surgical results, chromophobe, late results - - - - - 861
— — — — — — — nasopharyngeal extensions - - 897
— — — — — — — operation *v.* X-ray therapy - - 878
— — — — — — — post-operative clots 893
— — — — — — — surgical mortality statistics - - 821
— — — — — — — transfrontal *v.* transsphenoidal operation - - 242, 881
— — — — — — — treatment of recurrences - - 882
— — — — — clinical material - 812
— — — — — introduction - - 812
— — — — operative procedures employed - - 816
— — — — — pathology - - - 813
— — — — — summary - - - 918
— — — — — X-ray treatment - 867
— — transfrontal decompression of, risks and complications - 242
— — transsphenoidal decompression of 242
— — — — case reports - - - 246
— — — — commentary on cases - 252
— — — — conclusion - - - 252
Plasma-volume (*see* Blood-volume)
Plasmocytoma of innominate bone - 90
— — — case reports - - - 90
— — — discussion - - - - 93
Plaster treatment for osteo-arthritic protrusio acetabuli - - - 698
Pleura, endothelioma of - - - 314
— — comment - - - - - 317
— — two case reports - - - 314
Pleural effusions in bronchial carcinoma 183
— reflex at operation for lung resection 174
Pleurisy, sero-fibrinous, induction of before pneumonectomy - - 185
Pleuro-œsophageal fistula, cases of uncertain aetiology - - - 50
— — in empyema - - - - 46
— — — case report - - - - 46
— — — discussion - - - - 50
— — — pathogenesis - - - 51
— — — summary - - - - 53
— — — synopsis of cases from literature 49
— — — treatment and results - - 52
Pneumonectomy (*see also* Lung, Tumours of)
— for carcinoma of bronchus - - 186
Pneumothorax preliminary to pneumonectomy - - - - - - 185
Polya gastrectomy, gastroscopic appearance after - - - - - - 41
Polyp of stomach, gastroscopic appearance of - - - - - - 43
Polypus, œsophageal, accompanied by tumour of accessory thyroid gland 193
Ponceau fuchsine stain for virilism - 930
Post-operative conditions of stomach, gastroscopic appearances - - 41
Post-partum tumours of breast - - 772

PAGE

Postural methods of combating 'black out' in aviation - - - 755
Pregnancy in aetiology of obturator hernia 521
— cancer of breast and - - - 775
— physiological changes in breast during 769
Pregnane-diol and -triol, isolation of 933
Pressure on body in causation of 'black out' in aviation - - - 755
Pronephros in development of excretory system - - - - - - 500
Protrusio acetabuli - - - - 670
— — aetiology - - - - - 692
— — author's case reports, deep acetabula - - - - 681
— — — — — primary bilateral protrusions - - - 672
— — — — — — unilateral protrusions - - - 679
— — — — — secondary protrusions 682
— — clinical aspects - - - - 690
— — complications - - - - 692
— — diagnosis - - - - - 697
— — fundamental features - - 689
— — historical note - - - - 670
— — osteo-arthritic degeneration and 700
— — pelvimetry in - - - - 684
— — radiological characteristics - 686
— — treatment - - - - - 697
Psammom der Dura Mater - - 594
Pseudo-arthrosis in ununited fractures of femur neck - - - - - 739
Psychological aspect of surgery of adrenal cortex - - - - - - 934
Psychoses following transsphenoidal approach to pituitary adenoma - 877
Puberty, precocious, in females in osteitis fibrosa disseminata - - - 711
Pulmonary arteries, anatomical - - 169
— reflex effects at operation for resection of lung tissue - - - 174
— resection (*see* Lung, Tumours of; Pneumonectomy)
— veins, anatomical - - - - 171
Pyloric stenosis, gastroscopic appearance in - - - - - - 41
Pyloroplasty, gastroscopic appearance after 41
Pylorus, malignant, gastroscopic appearance of - - - - - - 44
PYRAH, LESLIE N., and FOWWEATHER, F. S.: Urinary calculi developing in recumbent patients - - 98
Pyramidal signs in olfactory groove meningiomas - - - - - 141

QUADRANTAL defects in pituitary adenoma - - - - - - 828
— — — — case report - - - 854

RABAN, JOHN, LEEDHAM-GREEN, J. C., and BROMLEY, J. F.: Plasmocytoma of innominate bone - 90
Radial nerve and artery, relationships of branches of - - - - - 95

PAGE

Radiotherapy in plasmocytoma of innominate bone - - 91, 93
— post-operatively in chromophobe adenoma of pituitary 863, 870
— pre-operatively in chromophobe adenoma of pituitary - - 867
— to prevent periodic recurrences in cancer - - - - - - 120
— for recurrences in chromophobe adenoma of pituitary - - 870
— Riedel's thyroiditis (*see* Riedel's Thyroiditis)
— *v.* operation in chromophobe adenoma of pituitary - - - - - 878
Ranula of left submaxillary gland, congenital, case report - - 947
RAO, M. NARASIMHA, and KINI, M. G.: Granulomatous ulcers resembling tuberculous ulcers of the stomach 379

Rare Cases :—

Adenoma of the stomach - - 643
Carcinoma of the stomach and the rectum in the same patient - 201
A case of benign teratoma of the testicle in an infant - - - - 443
A case of congenital ranula of the left submaxillary gland - - 947
A case of intussusception of the normal appendix into the cæcum 444
A case of sarcoma in the infraspinatus muscle - - - - - - 439
A case of spontaneous absorption of bone - - - - - - 944
A case of traumatic severance of the common bile-duct - - - 646
Leiomyoma of the stomach - - 942
Primary solitary diverticulitis of the cæcum - - - - - - 200
An unusual finger accident - - 198
RAY, P. N., and TRIBEDI, B. P.: Primary actinomycosis of the breast - 30
Rectum, adenocarcinoma of, lymphatics in relation to - - - - - 491
— columnar-celled cancer of, lymphatics in relation to - - - - - 490
— and stomach, carcinoma of, in same patient, case report - - - 201
Recumbency, urinary calculus formation in (*see* Urinary Calculi)
Recurrent dislocation of shoulder-joint (*see* Shoulder-joint)
REDMAN, THIRZA, and HEWETSON, J. T.: Observations on simple and malignant pathological conditions of the breast - - - - - 768
Reflex effects during pulmonary resection 174
'Renal death' after operations for pancreatic disease - - - 407
— drainage affected by recumbency, calculus formation and - - 102
RENTON, J. MILL, CHARTERIS, ALEXANDER A., and HEGGIE, JAMES FERGUSON: Riedel's thyroiditis and its treatment by radium - - - 54

PAGE

Retractor for transsphenoidal approach to pituitary - - - - - 245
Retrobronchial artery, anatomical - 170
Retrograde passage of bougies through gastrostomy opening for œsophageal stricture - - - - - 569

Reviews and Notices of Books :—

Actinomycosis (Z. Cope) - - 657
The adrenal cortex and intersexuality (L. R. Broster et al.) 211
Akute Gliedmassendystrophie in ihrer Bedeutung für die Behandlungsmassnahmen in der Unfallchirurgie (B. Karitzky) - - - - - 655
Die Anatomie der Pleurakuppel (A. Hafferl) - - - - - 955
Die Arthroskopie (*Endoskopie des Kniegelenks*) (E. Vaubel) - - 656
A bibliography of the works of Ambroise Paré : Premier chirurgien e conseiller du roy (J. Doe) - 214
Il cancro della mammella (G. Coggi) 210
On the cause of gastric ulcers (R. Brummelkamp) - - - - 955
Celsus : De medicina (trans W. G. Spencer) - - - - - - 658
A cerebral atlas (R. J. A. Berry) - 956
Chirurgie der Lungen und des Brustfelles (A. Brunner) - - - 954
Clinica y terapéutica quirúrgicas de urgencia (M. C. Garcia and F. Doménech-Alsina) - - - 204
Diabetes und Chirurgie (A. W. Fischer) 656
Diagnostic roentgenology (R. Golden) 958
Diagnostik und therapeutische Indikationsstellung bei den chirurgischen Erkrankungen der Harnorgane (P. Janssen) - - - - - 453
Diagnostisch-therapeutische Technik für den Chirurgen (R. Geissendörfer) - - - - - - 205
Disability evaluation (E. D. McBride) 213
Diseases of the thyroid, parathyroids, and thymus (A. Crotti) - - 650
Emergency surgery (H. Bailey) - 204
Experience in the management of fractures and dislocations (ed. P. D. Wilson) - - - - - 951
The foot (N. C. Lake) - - 452
Fractures and dislocations for practitioners (E. O. Geckeler) - - 207
Fractures of the jaws (R. H. Ivy) - 953
Genital abnormalities, hermaphroditism, and related adrenal diseases (H. H. Young) - - - - 212
Gray's anatomy, descriptive and applied (ed. T. B. Johnston and J. Whillis) - - - - - 657
Hæmorrhoids (M. C. Pruitt) - 452
Hernia (L. F. Watson) - - 452
The hypothalamus (W. E. Le Gros Clark et al.) - - - - - 652
Illustrations of anatomy for nurses (E. B. Jamieson) - - - - 455

PAGE

Reviews and Notices of Books, *contd.*—
Industrial surgery : principles, problems, and practice (W. W. Lasher) 654
Innere Medizin in der Chirurgie (H. F. v. Kress and W. Kittler) 451
Kollaterale Entzündungszustände in der Urfallheilkunde (P. Sudeck) 656
Die Kriegsschussverletzungen der Gelenke und Knochen der Gliedmassen (D. K. Franz) - - 655
Das Kropsproblem (E. Bircher) - 652
The management of fractures, dislocations, and sprains (J. A. Key and H. E. Conwell) - - - 207
A manual of surgery for nurses (C. Wells) - - - - - 454
Mecanismo probable de la cancerización (A. Garibaldi) - - - 210
Meningiomas (H. Cushing and L. Eisenhardt) - - - 957
Minor medical operations (K. Harris and E. Harris) - - - 951
Modern Surgical technic (M. Thorek) 950
Pathologische Physiologie chirurgischer Erkrankungen (F. K. Kessel, F. Merke, and F. Meythaler, ed. Th. Naegeli) - - - - 955
The pituitary gland (ed. W. Timme, A. M. Frantz, and C. C. Hare) 653
Practical procedures (ed. Sir H. Rolleston and A. A. Moncrieff) 203
Practical proctology (L. A. Buie) - 208
The practice of urology (L. Herman) 654
Praktikum der Chirurgie (O. Nordmann) - - - - - - 203
Pratica chirurgica (V. Puccinelli) - 951
The principles and practice of rectal surgery (W. B. Gabriel) - - 209
Pye's surgical handicraft (ed. H. Bailey) - - - - - - 950
Röntgendiagnostik der Gelenke mittels Doppelkontrastmethode (J. Oberholzer) - - - - - 953
Röntgendiagnostik der Knochen und Gelenkkrankheiten (R. Kienböck) 954
Die Röntgentiefentherapie (H. Holfelder) - - - - - 453
St. Thomas's Hospital reports (ed. O. L. V. S. de Wesselow and C. Max Page) - - - - - 450
Der Schock und verwandte Zustände des autonomen Systems (E. Rehn) 213
A short practice of surgery (H. Bailey and R. J. McN. Love) - - 653
Speech training for cases of cleft palate (M. C. Oldfield) - - 207
Surface and radiological anatomy (A. B. Appleton, W. J. Hamilton, and I. C. C. Tchaperoff) - 214
Surgical anatomy of the head and neck (J. F. Barnhill) - - 206
Surgical diseases of the mouth and jaws (E. C. Padgett) - - 206
Surgical errors and safeguards (M. Thorek) - - - - - 204

PAGE

Reviews and Notices of Books, *contd.*—
Surgical nursing and after-treatment (H. C. R. Darling) - - - 455
The surgical treatment of hypertension (G. Crile, ed. Amy Rowland) - - - - - - 656
A synopsis of the diagnosis of the acute surgical diseases of the abdomen (J. A. Hardy) - - 451
Synopsis of genito-urinary diseases (A. I. Dobson) - - - 213
Technik der Knochenbruchbehandlung (L. Böhler) - - - 952
Textbook of experimental surgery (J. Markowitz) - - - 205
Textbook of neuro-radiology (C. P. G. Wakeley and A. Orley) - - 957
A text-book of surgical pathology (C. F. W. Illingworth and B. M. Dick) - - - - - - 653
A textbook of X-ray diagnosis (ed. S. C. Shanks, P. Kerley, and E. W. Twining) - - - 449
The therapeutic problem in bowel obstructions (O. H. Wangensteen) - - - - - - 209
Die Therapie der Thrombose (E. Friedländer) - - - - - 656
Transactions of the Institute of British Surgical Technicians - 215
The treatment of clinical and laboratory data (D. Mainland) - - 454
Tumori del rene (M. Pignalosa and M. Fernandez) - - - 955
Wundversorgung und Wundbehandlung (H. v. Seemen) - - 655

Reviews and Notices of Books (Authors) :—

Allen, C. et al. : *The adrenal cortex and intersexuality* - - - 211
Appleton, A. B., Hamilton, W. J., and Tchaperoff, I. C. C. : *Surface and radiological anatomy* - 214
Bailey, H. : *Emergency surgery* - 204
Bailey, H. : *Pye's surgical handicraft* (ed.) - - - - - 950
Bailey, H., and Love, R. J. McN. : *A short practice of surgery* - 653
Barnhill, J. F. : *Surgical anatomy of the head and neck* - - 206
Beattie, J., et al. : *The hypothalamus* 652
Berry, R. J. A. : *A cerebral atlas* 956
Bircher, E. : *Das Kropsproblem* - 652
Böhler, L. : *Technik der Knochenbruchbehandlung* - - - 952
Broster, L. R., et al. : *The adrenal cortex and intersexuality* - - 211
Brummelkamp, R. : *On the cause of gastric ulcers* - - - 955
Brunner, Alfred : *Chirurgie der Lungen und des Brustfelles* - 954
Buie, L. A. : *Practical proctology* 208
Butler, G. C., et al. : *The adrenal cortex and intersexuality* - - 211

PAGE

Reviews and Notices of Books, *contd.*—
Clark, W. E. Le Gros, et al.: *The hypothalamus* - - - 652
Coggi, G.: *Il cancro della mammella* 210
Conwell, H. E., and Key, J. A.: *The management of fractures, dislocations, and sprains* - - 207
Cope, Z.: *Actinomycosis* - - 657
Crile, G.: *The surgical treatment of hypertension* (ed. Amy Rowland) 656
Crotti, A.: *Diseases of the thyroid, parathyroids, and thymus* - - 650
Cushing, H., and Eisenhardt, L.: *Meningiomas* - - - - - 957
Darling, H. C. R.: *Surgical nursing and after-treatment* - - - 455
Dick, B. M., and Illingworth, C. F. W.: *A text-book of surgical pathology* - - - - - - 653
Dobson, A. I.: *Synopsis of genito-urinary diseases* - - - 213
Doe, J.: *A bibliography of the works of Ambroise Paré: Premier chirurgien e conseiller du Roy* - - 214
Doménech-Alsina, F., and Garcia, M. C.: *Clinica y terapéutica quirúrgicas de urgencia* - - 204
Dott, N. M., et al.: *The hypothalamus* - - - - - - 652
Eisenhardt, L., and Cushing, H.: *Meningiomas* - - - - - 957
Fernandez, M., and Pignalosa, M.: *Tumori del rene* - - - 955
Fischer, A. W.: *Diabetes und Chirurgie* - - - - - - 656
Frantz, A. M., et al.: *The pituitary gland* (ed.) - - - - - 653
Franz, D. K.: *Die Kriegsschussverletzungen der Gelenke und Knochen der Gliedmassen* - - 655
Friedländer, E.: *Die Therapie der Thrombose* - - - - - 656
Gabriel, W. B.: *The principles and practice of rectal surgery* - - 209
Garcia, M. C., and Doménech-Alsina, F.: *Clinica y terapéutica quirúrgicas de urgencia* - - 204
Garibaldi, A.: *Mecanismo probable de la cancerización* - - - 210
Geckeler, E. O.: *Fractures and dislocations for practitioners* - 207
Geissendörfer, R.: *Diagnostisch-therapeutische Technic für den Chirurgen* - - - - - - 205
Golden, R.: *Diagnostic roentgenology* 958
Greenwood, A. W., et al.: *The adrenal cortex and intersexuality* 211
Hafferl, A.: *Die Anatomie der Pleurakuppel* - - - - - 955
Hamilton, W. J., Appleton, A. B., and Tchaperoff, I. C. C.: *Surface and radiological anatomy* - - 214
Hardy, J. A.: *A synopsis of the diagnosis of the acute surgical diseases of the abdomen* - - 451

PAGE

Reviews and Notices of Books, *contd.*—
Hare, C. C., et al.: *The pituitary gland* (ed.) - - - - - 653
Harris, E., and Harris, K.: *Minor medical operations* - - - 951
Herman, L.: *The practice of urology* - - - - - - 654
Holfelder, H.: *Die Röntgentiefentherapie* - - - - - - 453
Illingworth, C. F. W., and Dick, B. M.: *A text-book of surgical pathology* - - - - - - 653
Ivy, R. H.: *Fracture of the jaws* 953
Jamieson, E. B.: *Illustrations of anatomy for nurses* - - - 455
Janssen, P.: *Diagnostik und therapeutische Indikationsstellung bei den chirurgischen Erkrankungen der Harnorgane* - - - 453
Johnston, T. B., and Whillis, J.: *Gray's anatomy, descriptive and applied* (ed.) - - - - - 657
Karitzky, B.: *Akute Gliedmassendystrophie in ihrer Bedeutung für die Behandlungsmassnahmen in der Unfallchirurgie* - - - 655
Kerley, P., Shanks, S. C., and Twining, E. W.: *A textbook of X-ray diagnosis* (ed.) - - - - - 449
Kessel, F. K., et al.: *Pathologische Physiologie chirurgischer Erkrankungen* - - - - - - 955
Key, J. A., and Conwell, H. E.: *The management of fractures, dislocations, and sprains* - - 207
Kienböck, R.: *Röntgendiagnostik der Knochen und Gelenkkrankheiten* 954
Kittler, W., and Kress, H. F. v.: *Innere Medizin in der Chirurgie* 451
Kress, H. F. v., and Kittler, W.: *Innere Medizin in der Chirurgie* 451
Lake, N. C.: *The foot* - - 452
Lasher, W. W.: *Industrial surgery: principles, problems, and practice* 654
Love, R. J. McN., and Bailey, H.: *A short practice of surgery* - 653
McBride, E. D.: *Disability evaluation* - - - - - - - 213
Mainland, D.: *The treatment of clinical and laboratory data* - 454
Markowitz, J.: *Textbook of experimental surgery* - - - - 205
Marrian, G. F., et al.: *The adrenal cortex and intersexuality* - - 211
Merke, F., et al.: *Pathologische Physiologie chirurgischer Erkrankungen* - - - - - - 955
Meythaler, F., et al.: *Pathologische Physiologie chirurgischer Erkrankungen* - - - - - - 955
Moncrieff, A. A., and Rolleston, Sir H.: *Practical procedures* (ed.) 203
Naegeli, Th.: *Pathologische Physiologie chirurgischer Erkrankungen* (ed.) - - - - - - 955

PAGE

Reviews and Notices of Books, *contd.*—
Nordmann, O.: *Praktikum der Chirurgie* - - - - - 203
Oberholzer, J.: *Röntgendiagnostik der Gelenke mittels Doppelkontrastmethode* - - - - - 953
Oldfield, M. C.: *Speech training for cases of cleft palate* - - - 207
Orley, A., and Wakeley, C. P. G.: *Textbook of neuro-radiology* - 957
Padgett, E. C.: *Surgical diseases of* the mouth and jaws - - 206
Page, C. M., and de Wesselow, O. L. V. S.: *St. Thomas's Hospital reports* (ed.) - - - 450
Patterson, J., et al.: *The adrenal cortex and intersexuality* - - 211
Pignalosa, M., and Fernandez, M.: *Tumori del rene* - - - - 955
Pruitt, M. C.: *Hæmorrhoids* - 452
Puccinelli, V.: *Pratica chirurgica* - 951
Rehn, E.: *Der Schock und verwandte Zustände des autonomen Systems* - - - - - - 213
Riddoch, G., et al.: *The hypothalamus* - - - - - - 652
Rolleston, Sir H., and Moncrieff, A. A.: *Practical procedures* (ed.) 203
Rowland, Amy: *The surgical treatment of hypertension* (ed.) - - 656
Seemen, H. v.: *Wundversorgung und Wundbehandlung* - - 655
Shanks, S. C., Kerley, P., and Twining, E. W.: *A textbook of X-ray diagnosis* (ed.) - - - - - 449
Spencer, W. G.: *Celsus: De medicina* (trans.) - - - - - 658
Sudeck, P.: *Kollaterale Entzundungszustände in der Unfallheilkunde* - - - - - - 656
Tchaperoff, I. C. C., Appleton, A. B., and Hamilton, W. J.: *Surface and radiological anatomy* 214
Thorek, M.: *Modern surgical technic* 950
Thorek, M.: *Surgical errors and safeguards* - - - - - 204
Timme, W., et al.: *The pituitary gland* (ed.) - - - - - 653
Twining, E. W., Shanks, S. C., and Kerley, P.: *A textbook of X-ray diagnosis* (ed.) - - - - - 449
Vaubel, E.: *Die Arthroskopie (Endoskopie des Kniegelenks)* - - 656
Vines, H. W. C., et al.: *The adrenal cortex and intersexuality* - - 211
Wakeley, C. P. G., and Orley, A.: *Textbook of neuro-radiology* - 957
Wangensteen, O. H.: *The therapeutic problem in bowel obstructions* 209
Watson, L. F.: *Hernia* - - 452
Wells, C.: *A manual of surgery for nurses* - - - - - - 454
Wesselow, O. L. V. S., and Page, C. M.: *St. Thomas's Hospital reports* (ed.) - - - - - 450

PAGE

Reviews and Notices of Books, *contd.*—
Whillis, J., and Johnston, T. B.: *Gray's anatomy, descriptive and applied* (ed.) - - - - - 657
Wilson, P. D.: *Experience in the management of fractures and dislocations* - - - - - 951
Young, H. H.: *Genital abnormalities, hermaphroditism, and related diseases* - - - - - - 212
Rib resection in pleuro-œsophageal fistula in empyema - - - - - 52
Riedel's thyroiditis and its treatment by radium - - - - - - 54
— — — — aetiology - - - 68
— — — — case reports - - - 55
— — — — clinical comment - - 56
— — — — histology of cases subsequently treated - - 64
— — — — pathology - - - 58
— — — — summary - - - 69
— — — — technical particulars - 56
ROWBOTHAM, G. F.: Epidermoids arising in the diploe of the bones of the skull - - - - - - 506
— — The hyperostoses in relation with the meningiomas - - - 593

SACCULAR aneurysms of internal carotid artery in cavernous sinus (*see* Carotid Aneurysms)
Sacro-coccygeal abscess in acute infective osteomyelitis of spine - - 80
SALSBURY, C. R.: The nerve to the extensor carpi radialis brevis - 95
Sarcoma in infraspinatus muscle, case report - - - - - - 439
— of intestine in children - - - 429
— — — age incidence - - - 431
— — — clinical picture - - - 432
— — — diagnosis - - - - 435
— — — frequency - - - - 431
— — — personal case reports - - 429
— — — sex incidence - - - 432
— — — summary - - - - 436
— — — treatment - - - - 436
— periodicity in - - - - - 116
— of small intestine, two unusual cases 540
Scalp, fœtal, lymphatics of - - - 471
Schanz osteotomy in ununited intracapsular fractures of femur neck 737
Scirrhous carcinoma of breast - 775, 777
— — diffuse, gastroscopic appearances of - - - - - - 44
Scotoma, central, in pituitary adenomata 828
— — — — case reports - - - 850
Sella turcica, recalcification of, after treatment for chromophobe pituitary adenoma - - - - - 877
Serum-bilirubin readings to determine degree of pancreatic obstruction 399
Serum-calcium estimations in recumbent cases with renal calculi - - 104
Sex changes, clinical study of - - 925

PAGE

Sex hormones, biological aspects - 939
— — male, biological tests for - - 932
— — — isolation of - - - - 933
— incidence in cancer of common bile-duct - - - - - - 758
— — obstructive jaundice - - - 394
— — obturator hernia - - - 521
— — protrusio acetabuli - - - 692
— — sarcoma of intestine in children 432
Shoulder-joint, recurrent dislocation of 23
— — — alleged causes - - - 23
— — — Bankart's operation - - 25
— — — fascial sling operation - - 376
— — — mechanism and cause of - 24
— — — operation for - - - 320
— — — plea for simple operation - 375
— — — summary and conclusions - 28
— — — various operations - - 23
Silver wire in treatment of common iliac aneurysm - - - - 626, 627
Simpson, Graham Scales, obituary - 922
Simpson-Smith, A.: Sarcoma of the intestine in children - - 429
Sinus cavernosus, saccular aneurysms of internal carotid artery in (*see* Carotid Aneurysms)
Sistrunk's method of removing thyro-glossal fistulæ - - - - - 714
Skin, arrangement of normal lymphatics of - - - - - - - - 466
— pigmentation in osteitis fibrosa disseminata - - - - - - 711
— traction in congenital dislocation of hip - - - - - - - 791
Skull (*see also* Cranial)
— epidermoids in diploe of bones of - 506
— — — — pathology - - - 512
— — — — summary - - - 514
SLESINGER, E. G., and JEMSON, J.: Carcinoma of the stomach and the rectum in the same patient - 201
SMITH, E. J. RADLEY: Detachment of the medial epicondyle of the humerus with displacement into the elbow-joint - - - 785
SMITH, N. ROSS: Massive necrosis of the muscles of the leg after operation for removal of a bone-graft from the tibia - - - - - 780
Smith-Petersen nail in fractures of femur neck (*see* Femur, Intracapsular Fracture of)
Sodium antimony tartrate in elephantiasis 89
Speculum, vaginal, evolution and development of - - - - - - 232
Sphenoid ridge meningiomas, inner group - - - - - - 146
— — — outer group - - - 158
Spinal anæsthesia for lobectomy and pneumonectomy - - - 184
— cord and canal, inflammation extending to, in acute infective osteomyelitis of spine - - 81
— epidural suppuration, with reference to osteomyelitis of vertebræ - 366

PAGE

Spinal epidural suppuration, with reference to osteomyelitis of vertebræ, anatomical considerations - - 366
— — — — — — case reports - - 367
— — — — — — discussion and conclusions - - 372
— — — — — — introduction - - 366
— — — — — — nomenclature - 366
— — — — — — pathology - - 367
Spine, hyperlordosis of, in protrusio acetabuli - - - - - - 691
— osteomyelitis of (*see* Osteomyelitis; Spinal Epidural Suppuration)
Splanchnic nerves in supply to lower end of œsophagus - 333 et seq.
Spleen, tuberculosis of, with tuberculous subphrenic abscess - - - 661
— — — — — — case report - - 662
— — — — — — commentary - - 667
— — — — — — summary - - 669
Spontaneous recovery from abdominal wounds - - - - - 226, 227
Sputum examination in bronchial carcinoma - - - - - 180
Staining for adrenal virilism - - 930
STAMMERS, F. A. R.: Spinal epidural suppuration, with special reference to osteomyelitis of the vertebræ - - - - - - 366
Staph. aureus in acute infective osteomyelitis of spine - - 79
Stenosis of bladder neck (*see* Bladder)
— œsophagus, (*see* Œsophagus)
— pyloric, gastroscopic appearance in 41
Sternoclavicular joint, recurrent dislocation of, operation for - - 320
Sternothyroid muscle changes in Riedel's thyroiditis - - - - - 64
Sterones of urine - - - - - 933
Stomach (*see also* Gastric; etc.)
— adenoma of, case report - - 643
— carcinoma of, gastroscopic appearances of - - - - - 43–45
— diverticulum of, gastroscopic appearance in - - - - - - 41
— granulomatous ulcers resembling tuberculous - - - - - 379
— hour-glass contraction of, gastroscopic appearance - - - - 41
— leather-bottle, gastroscopic appearance of - - - - - - 44
— leiomyoma of, case report - - 942
— nerve-supply of upper end of - - 337
— polyp of, gastroscopic appearance of 43
— and rectum, carcinoma of, in same patient, case report - - - 201
— tuberculosis of, case reports of granulomatous ulcers resembling 380
— — diagnosis - - - - - - 380
— — incidence of - - - - - 379
— — sources of infection - - - 379
— — varieties of infection of wall - 379
— volvulus of (*see* Volvulus)
Stone formation in relation to condition of bladder mucosa - - - 259

PAGE

Streptococcal ulceration, progressive, case report - - - - 254
— — — discussion - - - - 257
— — — summary - - - - 257
Struma lymphomatosa, Riedel's thyroiditis and - - - - - - - 58
Subcutaneous tissue, lymphatic vessels of - - - - - - - 470
Submaxillary gland, left, congenital ranula of, case report - - 947
Subphrenic abscess, tuberculous, with tuberculosis of spleen (*see* Spleen)
Subtemporal decompression for pituitary adenoma - - - - - - 820
Sugar-tolerance test in pancreatic disease - - - - - - 400
Sulcus chiasmatis, anatomical variations in, pituitary adenoma and - 850
Supernumerary lobes of lungs - - 168
Supraclinoid aneurysm, differential diagnosis from intracavernous carotid aneurysm - - - - - 291, 297
Suprasellar clot formation in transfrontal approach to pituitary adenomata 895
Surgical instruments, evolution and development of, head-saws - 457
— — — — vaginal dilator and speculum - - - - - 232
Sylvian extension of chromophobe pituitary adenoma - - - 901
Sympathectomy for cardiospasm - 341
Sympathetic nerve-supply to lower end of œsophagus - - - - 333
— — upper end of stomach - - 337
Syndrome, adrenogenital - - - 926
— of Foix - - - - - - 271
— Foster Kennedy, in olfactory groove meningiomas - - - 140, 163
Synovial fluid in mechanism of knee-joint - - - - - 702, 703
Syphilis, œsophageal conditions and 575
Syphilitic gastritis, gastroscopic appearance in - - - - - - 39

TAGETE leaf for dressing trephine wounds in Blanche Bay - - 2
Takan (needle) used by trephiners of Blanche Bay - - - - - 2
Tartrate, antimony sodium, in elephantiasis - - - - - - 89
Temporal extension of chromophobe pituitary adenoma - - - 901
Tene a babait (Blanche Bay trephiner) 2
Teratoma of testicle in infant, case report - - - - - - 443
Test, van den Bergh, in obstructive jaundice - - - - - 397, 399
Testicle, benign teratoma of, in infant, case report - - - - - 443
— malignant, periodicity in - - 115
Thalamic extension of chromophobe pituitary adenoma - - - 901
THOMAS, R. GLYN: Adamantinoma of the tibia - - - - - - 547

PAGE

THOMPSON, C. J. S.: The evolution and development of surgical instruments - - - - - 232, 457
Thoracic splanchnic nerves in supply to lower end of œsophagus 333 et seq.
Thoracotomy, exploratory, in bronchial carcinoma - - - - - 183
Thorotrast injections in study of lymphatic vessels - - - - - - 462
Thrombosis of pampiniform plexus - 806
Thyroglossal fistulæ, complete - - 714
— — — case reports - - - 716
— — — conclusions - - - - 720
— — — discussion - - - - 718
Thyroid, cancer of, periodicity in - 115
— granuloma of - - - - - 69
Thyroidal hernia (*see* Obturator Hernia)
Thyroiditis, ligneous - - - - 69
— Riedel's, and its treatment by radium (*see* Riedel's Thyroiditis)
Tibia, adamantinoma of - - - 547
— — case report - - - - - 547
— — summary - - - - - 553
— removal of bone-graft from, massive necrosis of leg muscles following 780
Tirip (Makadao coco-nut milk) to cleanse head wounds in Blanche Bay - 2
Tomography in bronchial carcinoma - 182
Tracheal compression in Riedel's thyroiditis - - - - - 59
Traction in extra-articular osteosynthesis for fractured neck of femur - 741
— skin, in congenital dislocation of hip - - - - - - - 791
Transfrontal decompression of pituitary adenoma (*see* Pituitary Adenomata)
Transsphenoidal decompression of pituitary adenoma (see Pituitary Adenomata)
Trauma in pathology of intracavernous carotid aneurysms - - - 293
Traumatic severance of common bile-duct, case report - - - 646
Trephiners of Blanche Bay, New Britain: their instruments and methods 1
TRIBEDI, B. P., and RAY, P. N.: Primary actinomycosis of the breast - 30
Tuberculosis of spleen with tuberculous subphrenic abscess (*see* Spleen) 661
— stomach (*see* Stomach)
Tuberculous subphrenic abscess with tuberculosis of spleen (*see* Spleen)
Tuberculum sellæ meningiomas - - 143
Tumeur perlée - - - - - - 506
Tumour(s) of accessory thyroid gland with œsophageal polypus - - 193
— carcinoid, of appendix (*see* Carcinoid Tumours)
— of lung (*see* Lung)
— producing olfactory disturbances - 143
TURNER, G. GREY: Non-malignant stenosis of the œsophagus - 555
TURNER, PHILIP: Acute infective osteomyelitis of the spine - - 71

PAGE

ULCER, anastomotic, gastroscopic appearance in - - - 41
— of cæcum (*see* Cæcum)
— gastric (*see* Peptic Ulcer)
— granulomatous, resembling tuberculous ulcers of stomach - - 379
— — — — — — — case reports - - 380
— jejunal, gastro-enterostomy for, gastroscopic appearance after - - 41
— peptic (*see* Peptic Ulcer)
Ulceration, progressive streptococcal, case report - - - - - 254
— — — discussion - - - - 257
— — — summary - - - - 257
Ulnar palsy due to detached medial epicondyle of humerus - - 788
Urea in blood in pancreatic disease xxvi, 400
Urine, increased calcium in, due to dehydration in aetiology of recumbency calculi - - - - - 101
Urinary calculi developing in recumbent patients - - - - - - 98
— — — — — case reports - - 109
— — — — — literature - - - 98
— — — — — morbid anatomy - 99
— — — — — pathogenesis - - 100
— — — — — summary - - - 111
— — — — — symptomatology - 106
— — — — — treatment - - - 107
— complications in acute infective osteomyelitis of spine - - 80
— infection in aetiology of recumbency calculi - - - - - - 105

VAGINAL dilator and speculum, evolution and development of - 232
Vagus nerve in relation to gastro-œsophageal junction - 333 et seq.
Van den Bergh test in obstructive jaundice - - - - - 397, 399
Vascular causes of non-tuberculous disease of epididymis - - 806
Vater, ampulla of, cancer in - - 757
Veins, pulmonary, anatomical - - 171
Venous strangulation of loop of bowel, blood-volume changes - - 423
Ventriculography in pituitary adenoma 821, 841, 844, 848
Vertebral body, blood-supply of - 79
Vesical (*see* Bladder)
Vi (knife) used by trephiners of Blanche Bay - - - - - - - 2
Virilism, adrenal - - - - - 927
— — a new stain for - - - - 930
Vision in classification of early results of surgery in pituitary adenoma - - - - - - 824
— impairment of, in acidophil pituitary adenomata - - - 908, 909
— — due to olfactory groove meningiomas - - - - - 129, 140
— — — sphenoid ridge meningiomas 148 et seq.

PAGE

Vision, normal, in pituitary adenomata - - - - - - - 829
— — — — case report - - - 859
Visit of Académie de Chirurgie de France to Royal College of Surgeons of England - - - - - - 240

Visits to Surgical Clinics at Home and Abroad :—

Altounyan of Aleppo - - - 412
Visual field charts in pituitary adenomata - 247 et seq., 830 et seq.
Vitamin-A deficiency in aetiology of recumbency calculi - - - 103
— diet, stone formation and - - 259
Vitamin-D excess in aetiology of recumbency calculi - - - - - 104
Voice changes in Riedel's thyroiditis - 56
Volvulus of stomach, diaphragmatic lesions with - - - - - 640
— — displacement of other organs - 640
— — ending in perforation, case report 630
— — factors favouring - - - 641
— — mechanics of - - - - 638
— — mesentero-axialis type - - 639
— — organo-axialis type - - - 640
— — partial - - - - - 640
— — surgical treatment - - - 641
— — with rare diaphragmatic hernia, case report - - - - 632
Vomiting due to olfactory groove meningiomas - - - - - 141

WAKELEY, CECIL P. G. : A case of benign teratoma of the testicle in an infant - - - - - 443
— — Obturator hernia, its aetiology, incidence, and treatment, with 2 personal operative cases - 515
— — Sarcoma in infraspinatus muscle 439
WALKER, A. LATIMER : Adenoma of the stomach - - - - - - 643
WEBSTER, J. H. DOUGLAS : Periodicity in cancer and other neoplastic diseases - - - - - - 113
Weight-bearing after intracapsular fractures of neck of femur - 727
Weight-extension apparatus (McFarland's) 793
White bile in pancreatic disease, significance of - - - - - - 408
WHITESIDE, W. CARLETON : A leaking non-specific aneurysm of the common iliac artery, with effective treatment by wiring - - 624
Wilkie, Sir David, obituary - - 390
Winslow, foramen of, hernia through, case report of occurrence in baby - - - - - - - 648
Wire guides for nailing fractures of femur neck, insertion of - - 742
Wiring of common iliac aneurysm (*see* Iliac Aneurysm)

PAGE

XANTHOCHROMIC cysts in chromophobe adenomata of pituitary 889
X-ray appearances in acute infective osteomyelitis - - - - 82
— — — — — — of spine - - 73, 74
— — adamantinoma of tibia 548, 551, 552
— — adenoma of stomach - - 643
— — after closed operation for intracapsular fractures of femur neck - - - - - 725
— — in bronchial carcinoma - - 182
— — calcification in epicondylar bursa at elbow - - - - 446
— — carcinoma of jejunum - - 537
— — complete thyroglossal fistulæ 716, 718
— — congenital dislocation of hip 792 et seq.
— — detached medial epicondyle of humerus - - - - 786
— — of epidermoid of skull - 508, 510
— — in granulomatous gastric ulcers resembling tuberculosis 381, 383, 384
— — hypertelorism - - - - 590
— — intracavernous carotid aneurysms 273 et seq.
— — of jaw after removal of ranula of left submaxillary gland - - 947
— — in leiomyoma of stomach - - 942
— — of lymphatic plexus of foot - 474

PAGE

X-ray appearances in meningiomas of inner sphenoid ridge - 149, 153
— — — outer sphenoid ridge - - 159
— — — with cranial hyperostoses 600 et seq.
— — of normal hip-joint - - - 701
— — in olfactory groove meningioma 130, 141, 163
— — osteitis fibrosa disseminata - 707
— — pituitary adenoma 247, 249, 251, 841, 844, 848, 898
— — plasmocytoma of innominate bone 91, 92, 93
— — pleuro-œsophageal fistula in empyema - - - - 46
— — protrusio acetabuli - 673 et seq.
— — of recumbency calculi - - 109
— — shoulder after removal of sarcoma of infraspinatus muscle - - 442
— — in spontaneous absorption of bone 945, 946
— — stricture of œsophagus 563, 570, 574, 577
— — of subcutaneous lymphatics in fœtus - - - - - 471
— — subphrenic abscess - - - 664
— therapy (*see* Radiotherapy)

ZINC peroxide in streptococcal ulceration - - - - - - 256

PRINTED IN GREAT BRITAIN BY JOHN WRIGHT AND SONS LTD., BRISTOL

HARVEY CUSHING, M.D.

JUN 6 1939 No. 104

...ttish Surgery

... & SONS LTD.
...PKIN MARSHALL LTD.
... COMPANY, BALTIMORE, Sole Agents.
... under the Act of March 3, 1879. (Sec. 412 P. L. & R.)

worthy of note!

HOSPITAL

ABLE

ING POSITION WITH THIRD SECTION
TED TO RELAX ABDOMINAL MUSCLES

TIONED AND SPECIAL FITTINGS
ED FOR THOMACOPLAST

SOCIATION Ltd.

WIMPOLE STREET, W.1

EDINBURGH
Twist Place